Principles of Gynecologic Oncology Surgery

PEDRO T. RAMIREZ
MICHAEL FRUMOVITZ
NADEEM R. ABU-RUSTUM

ELSEVIER
Principles of Gynecologic Oncology Surgery

PEDRO T. RAMIREZ, MD
Professor
David M. Gershenson Distinguished Professor in Ovarian Cancer Research
Director of Minimally Invasive Surgical Research and Education
Department of Gynecologic Oncology and Reproductive Medicine
The University of Texas MD Anderson Cancer Center
Houston, Texas

MICHAEL FRUMOVITZ, MD, MPH
Professor and Fellowship Director
Department of Gynecologic Oncology and Reproductive Medicine
The University of Texas MD Anderson Cancer Center
Houston, Texas

NADEEM R. ABU-RUSTUM, MD
Chief, Gynecology Service
Professor, Weill Cornell Medical College
Vice Chair Technology
Department of Surgery
Memorial Sloan Kettering Cancer Center
New York, New York
To my father, Tomas, and my mother, Juanita, who sacrificed it all so that our family could have a better future. To my sister, Maria, for her consistent support and loyalty.

To my children, Gabriela, Peter, Johnny, Sofia, and Emma, for the love and happiness they bring each day.

To my wife, Gloria, for her sacrifices, patience, encouragement, support, constant inspiration, and most important, her love.

Pedro T. Ramirez

To my wife, Amie, and my children, Robert, Natalie, and Andrew. Thank you for your love and encouragement.

Nadeem R. Abu-Rustum

To my wife, Karen, and sons, Alex and Jonathan, for enduring countless hours and Sunday mornings away from home and for my father, Billy, who would have been incredibly proud and although a general gynecologist, would have read this book cover to cover, relishing every page.

Michael Frumovitz
Nadeem R. Abu-Rustum, MD
Chief, Gynecology Service
Professor, Weill Cornell Medical College
Vice Chair Technology
Department of Surgery
Memorial Sloan Kettering Cancer Center
New York, New York

David M. Adelman, MD, PhD, FACS
Associate Professor
Division of Plastic Surgery
The University of Texas MD Anderson Cancer Center
Houston, Texas

Giovanni Aletti, MD
Associate Professor in Obstetrics and Gynecology
University of Milan
Director, Unit of New Therapeutic Strategies in Ovarian Cancer
European Institute of Oncology
Milan, Italy

Mara B. Antonoff, MD
Assistant Professor
Department of Thoracic and Cardiovascular Surgery
The University of Texas MD Anderson Cancer Center
Houston, Texas

Anne-Sophie Bats, MD
Paris Descartes University
Sorbonne Paris Cité
School of Medicine
Assistance Publique–Hôpitaux de Paris
Hôpital Européen Georges-Pompidou
Gynecological and Breast Cancer Surgery
Paris, France

David M. Boruta, MD
Associate Professor
Department of Obstetrics and Gynecology
Tufts University School of Medicine
Chief of Gynecologic Oncology
Steward Health Care System
Boston, Massachusetts

Robert Bristow, MD, MBA
Professor and Chair
Obstetrics and Gynecology
University of California, Irvine School of Medicine
Orange, California

Jvan Casarin, MD
Research Fellow
Division of Gynecologic Surgery
Mayo Clinic
Rochester, Minnesota

Luis M. Chiva, MD, PhD
Chair of Department of Obstetrics and Gynecology
University of Navarra
Madrid, Spain

David Cibula, MD, PhD
Gynecologic Oncology Center
Department of Obstetrics and Gynecology
First Faculty of Medicine
Charles University in Prague and General University Hospital in Prague
Prague, Czech Republic

Kathryn G. Cunningham, MD
Fellow
Department of Urology
The University of Texas MD Anderson Cancer Center
Houston, Texas

Pedro F. Escobar, MD, FACOG, FACS
Instituto Gyneco-Oncológico
San Juan, Puerto Rico
Associate Clinical Professor of Surgery
Cleveland Clinic
Cleveland, Ohio

Ramez N. Eskander, MD
Assistant Clinical Professor
Division of Gynecologic Oncology
Department of Reproductive Medicine
University of California San Diego
Moores Cancer Center
La Jolla, California

Anna Fagotti, MD
Division of Gynecologic Oncology
Catholic University of the Sacred Heart
Rome, Italy

Gwenael Ferron, MD, PhD
Department of Surgical Oncology
Institut Claudius Regaud–Institut Universitaire du Cancer
Toulouse, France

Katherine Fritton, MD
Department of Gynecology and Obstetrics
The Johns Hopkins University
Baltimore, Maryland

Michael Frumovitz, MD, MPH
Professor and Fellowship Director
Department of Gynecologic Oncology and Reproductive Medicine
The University of Texas MD Anderson Cancer Center
Houston, Texas
Fabio Ghezzi, MD
Professor and Head
Department of Obstetrics and Gynecology
University of Insubria
Varese, Italy

Gretchen E. Glaser, MD
Consultant
Division of Gynecologic Surgery
Mayo Clinic
Rochester, Minnesota

Tam T.T. Huynh, MD
Department of Thoracic and Cardiovascular Surgery
Department of Interventional Radiology
The University of Texas MD Anderson Cancer Center
Houston, Texas

Maria D. Iniesta, MD, PhD
Senior Coordinator Clinical Studies
Department of Gynecologic Oncology and Reproductive Medicine
The University of Texas MD Anderson Cancer Center
Houston, Texas

Anuja Jhingran, MD
Department of Radiation Oncology
Division of Radiation Oncology
The University of Texas MD Anderson Cancer Center
Houston, Texas

Jose A. Karam, MD
Assistant Professor
Department of Urology
The University of Texas MD Anderson Cancer Center
Houston, Texas

Anna Kuan-Celarier, MD
Resident
Department of Obstetrics and Gynecology
Louisiana State University Health Science Center
New Orleans, Louisiana

Eric Leblanc, MD
Head, Department of Gynecologic Oncology
Centre Oscar Lambret
Lille, France

Fabrice Lécuru, MD, PhD
University Paris Descartes
Sorbonne Paris Cité
School of Medicine
Assistance Publique–Hôpitaux de Paris
Gynecological and Breast Cancer Surgery
Paris, France

Mario M. Leitao, Jr., MD
Attending Gynecologic Oncologist
Department of Surgery
Memorial Sloan Kettering Cancer Center
Professor of Obstetrics and Gynecology
Weill Cornell Medical College
New York, New York

Javier Magrina, MD
Director of Minimally Invasive Gynecologic Surgery
Mayo Clinic
Scottsdale, Arizona
President, Fellowship Board of Directors
American Association of Gynecologic Laparascopists
Cypress, California

Andrea Mariani, MD, MS
Professor
Division of Gynecologic Surgery
Mayo Clinic
Rochester, Minnesota

Alejandra Martinez, MD
Department of Surgical Oncology
Institut Claudius Regaud–Institut Universitaire du Cancer
Toulouse, France

Patrice Mathevet, MD, PhD
Department of Gynecology
CHU Vadois
Lausanne, Switzerland

Reza J. Mehran, MD
Department of Thoracic and Cardiovascular Surgery
The University of Texas MD Anderson Cancer Center
Houston, Texas

Craig A. Messick, MD
Assistant Professor of Surgery
Department of Surgical Oncology
Section of Colon and Rectal Surgery
The University of Texas MD Anderson Cancer Center
Houston, Texas

Bassem Mezghani, MD
Department of Surgical Oncology
Institut Claudius Regaud–Institut Universitaire du Cancer
Toulouse, France
Salah Azaiz Cancer Institute
Tunis, Tunisia

Lucas Minig, MD, PhD
Head
Department of Gynecology
Instituto Valenciano de Oncologia
Valencia, Spain

Miziana Mokbel, MD
Assistance Publique–Hôpitaux de Paris
Hôpital Européen Georges-Pompidou
Gynecological Cancer and Breast Cancer Surgery
Paris, France

Camilla Nero, MD
Division of Gynecologic Oncology
Catholic University of the Sacred Heart
Rome, Italy
Crystal Nhieu, MD, BS  
Resident  
Department of Obstetrics and Gynecology  
Louisiana State University Health Science Center  
Baton Rouge, Louisiana

Rene Pareja, MD  
Department of Gynecologic Oncology  
Instituto Nacional de Cancerología  
Bogotá, Colombia  
Clínica de Oncología Astorga  
Medellín, Colombia

Manuel Penalver, MD  
Chairman, Department of Obstetrics and Gynecology  
Herbert Wertheim College of Medicine  
Florida International University  
Miami, Florida

George T. Pisimisis, MD  
Department of Thoracic and Cardiovascular Surgery  
Department of Interventional Radiology  
The University of Texas MD Anderson Cancer Center  
Houston, Texas

Pedro T. Ramirez, MD  
Professor  
David M. Gershenson Distinguished Professor in Ovarian Cancer Research  
Director of Minimally Invasive Surgical Research and Education  
Department of Gynecologic Oncology and Reproductive Medicine  
The University of Texas MD Anderson Cancer Center  
Houston, Texas

Reitan Ribeiro, MD  
Surgical Oncologist  
Medical Residency Director  
Department of Surgical Oncology  
Erasto Gaertner Hospital  
Curitiba, Brazil

Emery Salom, MD  
Clerkship Director and Assistant Professor  
Florida International University  
College of Medicine  
Division of Gynecologic Oncology  
Miami, Florida

Gloria Salvo, MD  
Department of Gynecologic Oncology and Reproductive Medicine  
The University of Texas MD Anderson Cancer Center  
Houston, Texas

David A. Santos, MD  
Assistant Professor of Surgery  
Department of Surgical Oncology  
The University of Texas MD Anderson Cancer Center  
Houston, Texas

Giovanni Scambia, MD  
Division of Gynecologic Oncology  
Catholic University of the Sacred Heart  
Rome, Italy

Brooke A. Schlappe, MD  
Gynecologic Oncology Fellow  
Department of Surgery  
Memorial Sloan Kettering Cancer Center  
New York, New York

Yukio Sonoda, MD  
Gynecologic Oncologist  
Department of Surgery  
Memorial Sloan Kettering Cancer Center  
New York, New York

Edward Tanner, MD  
Assistant Professor  
Department of Gynecology and Oncology  
The Johns Hopkins University  
Baltimore, Maryland

Audrey T. Tsunoda, MD, PhD  
Surgical Oncologist  
Department of Surgical Oncology  
Erasto Gaertner Hospital  
Curitiba, Brazil

Stefano Uccella, MD, PhD  
Consultant  
Department of Obstetrics and Gynecology  
University of Insubria  
Varese, Italy

Giuseppe Vizzielli, MD  
Division of Gynecologic Oncology  
Catholic University of the Sacred Heart  
Rome, Italy

Vanna Zanagnolo, MD  
Division of Gynecology  
European Institute of Oncology  
Milan, Italy

Oliver Zivanovic, MD  
Attending Physician  
Department of Surgery  
Memorial Sloan Kettering Cancer Center  
New York, New York
The first edition of *Principles of Gynecologic Oncology Surgery* capitalizes on the talents of three world-renowned experts in the field of gynecologic cancer surgery. Drs. Ramirez, Frumovitz, and Abu-Rustum have used the vast expertise of leaders in the field—in the United States and abroad—to produce one of the most comprehensive textbooks on the surgical management of patients with gynecologic cancer. In the textbook’s first section, “Anatomy and Principles of Surgery,” the editors and authors provide their readers with in-depth descriptions of basic principles of anatomy required for radical upper abdominal and pelvic surgery. The authors also integrate detailed highlights of all the items in the guidelines for the timely issue of Enhanced Recovery After Surgery (ERAS). The subsequent sections focus on detailed descriptions of surgical procedures according to anatomic site of disease, including vulvar, cervical, uterine, and ovarian cancer. For each disease site, individual chapters explore intricate surgical procedures, including state of the art techniques of sentinel lymph node mapping for cervical and endometrial cancers. In addition, the disease chapters provide a comprehensive review of surgical techniques. For cervical cancer this includes the entire spectrum of surgical procedures from conservative fertility-sparing procedures for early stage disease to radical surgery for more advanced disease, with a separate section highlighting ultraradical pelvic exenteration for recurrent disease. The ovarian cancer section provides a comprehensive roadmap for the surgical management of this disease, including indications for laparoscopic assessment for cytoreduction through radical upper abdominal procedures and intestinal surgery for the debulking of advanced ovarian cancer.

In addition to the chapters on surgical management of gynecologic cancers, one of the major strengths of *Principles of Gynecologic Oncology Surgery* is its coverage of surgery on the gastrointestinal and urinary tracts, as well as the management of surgical complications associated with these procedures. Finally, the management of complications associated with radiation therapy, as well as techniques in pelvic reconstruction and the role of minimally invasive approaches with laparoscopic and robotic techniques, provides for a well-rounded and comprehensive textbook.

*Principles of Gynecologic Oncology Surgery* is destined to be an authoritative, high-quality resource in the field for years to come, whether for a resident, fellows in training, or a well-established practitioner. This textbook will play a significant role in developing and sharpening the skills of those dedicated to the surgical treatment of women with gynecologic cancer.

*Richard R. Barakat, MD*
Preface

In gynecologic oncology surgery, the surgeon must have a detailed understanding of the anatomy and basic principles of radical abdominal and pelvic surgery. In addition, each surgeon must have a vast fund of knowledge about diagnosing and managing complications related to such complex surgical procedures. In this first edition of Principles of Gynecologic Oncology Surgery, we aim to provide a comprehensive surgical textbook that will serve not only experienced surgeons in gynecologic oncology but also trainees and all those interested in learning the pertinent details related to various topics of surgery for each disease site in gynecologic cancers. The guiding principles for any gynecologic surgeon are (1) to understand the relevant and updated literature related to a disease site or surgically related topic, (2) to have a solid understanding of the principles of evaluation and management of most surgical scenarios in gynecologic oncology surgery, and (3) to derive treatment based on the most up-to-date published literature.

This book is intended for all who wish to have a step-by-step guide to the most commonly performed procedures in gynecologic oncology. Our intent is for students of surgery, both novice and experienced, to have a classic textbook where they can go not only to find the most relevant and concise source of literature on a particular subject but also to seek details on the specific and key steps of surgical procedures and where they can learn the ideal approach for each step of the surgery from leading surgeons throughout the world.

The world of surgery in gynecologic oncology is evolving at a fast pace. Surgeons today are required to have a mastery of innumerable approaches to gynecologic cancer surgery and are expected to become proficient not only in open surgery but also in minimally invasive surgery, such as laparoscopy and robotic surgery. New tools are constantly being developed that demand the surgeon’s time and skill, particularly in the early learning phases. In addition, surgeons are expected to learn new approaches in the management of gynecologic cancers, such as sentinel lymph node mapping, with the understanding that the quality of the surgery dictates whether a patient will have a full lymphadenectomy or be spared such a procedure and potentially avoid its associated adverse effects. This evolution of surgical education has changed the methods by which surgeons acquire the necessary skills to perform gynecologic oncology surgery, and these include surgical simulators, web-based surgical training, seminars on video series, and live television. These are among some of the most common avenues for learning today, and therefore surgeons must adapt to this wave of “nontraditional” learning. In this textbook, we aim to provide such video-based teaching when applicable. Surgeons will be able to observe some of the most skilled surgeons in the world performing procedures of high complexity that will surely supplement and improve the surgical skills and practice of each reader.

The goal of this textbook is to provide a format designed so that surgeons will have quick and easy access to relevant information—a textbook that will present information that is simple to understand and fast to apply. In other words, we hope that surgeons will use this book as a tool that will allow them to go over the steps of each procedure just before entering the operating room. We have compiled chapters that will serve as a roadmap to navigate the complex anatomy of the abdomen or pelvis, with figures and illustrations that will provide descriptive strategies to achieve the best results in the surgery. Video demonstrations, when applicable, will also allow the reader to have immediate access to the operating room of the skilled surgeons who wrote each chapter and to learn from them the secrets to the success of their surgical approach. The success of this textbook rests on the contributions from each of the internationally renowned chapter authors. They have all put in a tremendous amount of effort in writing and editing of the chapters. In addition, the entire project would not have been possible without the tremendous amount of work, guidance, patience, and experience of the Elsevier editing team. We are deeply grateful to all who have contributed to this textbook.

Finally, we are indebted to our mentors who, since early in our careers, took the time and the effort to teach us their approach and to provide us with the best “tips and tricks” to make complex surgical procedures more feasible. Their constructive criticism and detailed explanations are the essence of this textbook. The inspiration they provided is translated in the pages of this textbook as a testament to the legacy that each of our surgical mentors instilled in us. Our duty is to see that this textbook serves as a tool that will enable gynecologic oncology surgeons throughout the world to provide the best and most comprehensive surgical care to patients with gynecologic cancers. We are also grateful to our patients who not only endure the burden of disease but also allow us the privilege, every day, to care for them. The gynecologic oncology surgeon must remind himself or herself every day that he or she is gifted with the amazing responsibility of eradicating cancer, and that to fulfill this honorable task, we must seek each day to expand our fund of knowledge, enhance our surgical skills, and integrate new and novel approaches and technology. Most of all, though, we must seek to remain humble in the face of such profound responsibility. Let us all remember that each time we enter the operating room, our fate and that of our patient lie not only in the skills of our hands or the capacity of our tools but more so on our ability to make sound decisions that will always prioritize, above all, the well-being of our patients. We hope that this textbook will serve all who read it to become not only better surgeons and clinicians but also better doctors.

Pedro T. Ramirez, MD
Michael Frumovitz, MD
Nadeem Abu-Rustum, MD
The modern era of gynecologic oncology surgery began in the 20th century with groundbreaking work by pioneering surgeons who explored novel surgical options for women with gynecologic malignancies. Gynecologic oncology was not approved as a subspecialty of obstetrics and gynecology until 1973, when the American Board of Medical Specialties approved it as a special qualification. Subsequently, the Society of Gynecologic Oncology (SGO) was created, and much of the credit for its foundation must be given to Hervy E. Averette and John J. Mikuta. The first scientific meeting of the SGO was held in Key Biscayne, Florida, in 1969.

Over the course of the past century, this specialty has witnessed tremendous advances in surgical technique and indications. Major innovations have been seen in imaging, cancer detection, sentinel lymph node mapping, and technology with the introduction of laparoscopy and robotic surgery. The field has shifted from very aggressive and deforming procedures to more precise and conservative approaches. Women with gynecologic cancer have options that would never even have been considered until just a few years ago. In tumors of the vulva, patients no longer undergo morbid radical tumor resection along with extensive groin lymphadenectomy. Extensive work evaluating the role of local excision combined with sentinel lymph node alone has led to the current tailored approaches offered to patients and thus a decrease in rates of perioperative complications and long-term side effects, such as debilitating lymphedema. The management of cervical cancer has evolved from the times of ultraradical surgery, such as radical hysterectomy, to modified radical surgery, fertility-preserving radical trachelectomy, or simple conization. Patients with early cervical cancer should no longer be exposed to extensive lymphadenectomy but, rather, should undergo selective and targeted sentinel lymph node mapping. For patients with locally advanced cervical cancer, the role of pretreatment selective lymph node dissection has been established as a tool to more definitively focus on the area of interest for radiation therapy. In patients with endometrial cancer, laparoscopy or robotic surgery has provided impressive outcomes, including fewer intraoperative and postoperative complications, when compared with open surgery. Sentinel lymph node mapping algorithms have also become standard of care in most centers, thus allowing patients to undergo less morbid procedures with faster recoveries. More recently, hysteroscopic resection of endometrial tumors in patients with low-risk disease has allowed young women interested in future fertility to undergo treatment that spares the uterus while at the same time treats the cancer. Even in the setting of advanced ovarian cancer, patients are more appropriately selected for up-front cytoreductive surgery or neoadjuvant chemotherapy according to the results of increasingly more accurate imaging modalities and through the direct assessment of abdominal tumor burden by means of laparoscopic surgery. Similarly, improvements in perioperative management and critical care allow surgeons to be much more aggressive when performing cytoreductive surgery or exenterative procedures in patients selected to undergo tumor debulking for advanced ovarian cancer.

*Principles of Gynecologic Oncology Surgery* is a broad and comprehensive textbook for all surgeons whose primary practice involves the care of women with gynecologic cancers. In each chapter, the reader learns the latest and most clinically relevant updates from the published literature on the topic of focus that particular chapter. In addition, each chapter presents information in a format that is practical in the management of patients with gynecologic malignancies. For each disease site, the reader should appreciate standard recommendations in the initial evaluation, the preoperative workup, the step-by-step approach to the surgical procedures pertinent to that disease site, and the postoperative evaluation in the setting of complications for each of the procedures presented.

A number of chapters address topics that are all-encompassing in the field of gynecologic oncology surgery. These include chapters on Enhanced Recovery After Surgery, which is a topic of significant impact in the perioperative care of all surgical patients but one that is becoming increasingly more important in all women undergoing gynecologic surgery. In that chapter, the authors outline the current guidelines to be implemented in any Enhanced Recovery After Surgery program, with an emphasis on the importance of compliance with each of these guidelines and, ultimately, a summary of the outcomes associated with the implementation of such programs. The textbook
also provides information on related and relevant surgical topics such as surgery of the intestinal and urinary tract, as well as reconstructive surgery. In each of these chapters, experts in the respective fields provide their approach in performing procedures within their area of expertise that are pertinent to gynecologic oncology surgery. Each provides tips and tricks in how to achieve the best results when performing complex procedures. Their valuable input allows gynecologic oncology surgeons to gain insight into the perspective brought by each of these specialists when consulted.

The work presented in this textbook is a composite representation of the outstanding contributions made to the field of gynecologic oncology by innumerable investigators over many years. The information presented in each chapter pays tribute to the endless hours and to the unselfish commitment that such individuals have made to improve the outcome of women with gynecologic cancers. Their innovative thinking and courage to explore beyond the status quo will continue to inspire those in all corners of the globe who continue to strive to find better strategies for prevention, diagnosis, management, and surveillance of gynecologic cancers. In this work, the amazing contribution of many patients must also be recognized. Through the history of this field, these patients have endured the impact of gynecologic cancers, and through their courage, they helped advance this field. These are patients who, in light of limited data at different times through history, accepted new diagnostic and surgical approaches, who agreed to be among the firsts by enrolling in promising surgical trials, and who gave of themselves so that others in the future could undergo better and more targeted treatment. With this textbook, tribute is paid to these patients—the true heroes who have left a lasting mark on this field.
Anatomy is to physiology as geography is to history; it describes the theater of events.
JEAN FRANÇOIS FERNEL

All gynecologic oncology surgeons should be familiar with the anatomy of the abdomen and pelvis to perform all complex and radical procedures required in the surgical management of women with gynecologic tumors. There has been an increasing emphasis on the role of upper abdominal surgery, particularly in the setting of advanced ovarian cancer. Therefore it is imperative that surgeons understand the detailed anatomy of the upper abdomen, in addition to the pelvic anatomy. A strong emphasis should be placed on the training of surgeons embarking on a career in gynecologic oncology to impart to them the skills and abilities to become proficient in surgery of the abdomen and pelvis. Gynecologic oncologists must understand the principles of multiple surgical disciplines, such as hepatobiliary surgery, urologic surgery, colorectal and intestinal surgery, and vascular surgery. The goal of this chapter is to provide surgeons with the anatomic details of the abdomen and pelvis. The material presented here aims to describe all structures relevant to the gynecologic oncologist.

**Pelvic Anatomy**

Pelvic anatomy remains the primary domain of the gynecologic surgeon. As a result, all who perform surgery in the pelvis should be thoroughly familiar with its intricate anatomic landmarks. The pelvic anatomy is complex and requires a great deal of expertise, given its detailed vascular and nerve structure, which demands the surgeon's careful attention to the steps of the procedures. The consequences of severe complications, such as severe hemorrhage from vascular lacerations; fistulas of the urinary or gastrointestinal tract from injury to structures such as ureters, bladder, or bowel; and neuropathic injuries from lacerations or thermal injuries to nerves may all be potentially avoided by the surgeon's devoting time to learning the complex anatomy of the pelvis (Fig. 2.1).

**Bony Pelvis**

The bones that form the pelvis of the newborn are the ilium, ischium, pubis, sacrum, and coccyx. The ilium, ischium, and pubis join together at the age of 16 to 18 years to form a single bone, called the pelvic bone. Accordingly, in the adult, the bones of the pelvis comprise the right and left pelvic bones, the sacrum, and the coccyx (Fig. 2.2). This bony pelvis is a firm structure to which all the pelvic ligaments and muscles are attached.

**Ilium**

The upper part of the pelvic bone is the ilium. Its superior aspect enlarges to form a flat wing that provides support for the muscles of the lower abdomen; it is also called the “false pelvis.” The medial surface of the ilium has two concavities forming the lateral borders of the pelvic channel. The superior and larger of these two concavities is the greater sciatic notch, and the ischial spine is its most prominent landmark.

**Ischium**

The ischium is the posterior and inferior part of the pelvic bone. The ischial spine marks the posterior margin of the bone.

**Pubis**

The anterior and inferior part of the pelvic bone is the pubis. The superior and inferior pubic branches are located anteriorly and articulate in the midline at the pubic symphysis.

**Sacrum**

The sacrum is composed of five sacral vertebrae that are fused together. Nerve outlets are positioned anterior and laterally; the sacral nerves run through them. The coccyx is attached inferiorly and is the posterior border of the pelvic outlet (Fig. 2.3).

**Orientation of the Bony Pelvis**

Typically, surgeons operate with the pelvis in the horizontal position. However, in the erect woman the pelvis is naturally oriented so that the anterior superior iliac spine and the front
edge of the pubic symphysis are in the same vertical plane, perpendicular to the ground. Therefore the pelvic inlet is tilted anteriorly, and the urogenital hiatus is parallel to the ground. This directs the pressure of the pelvic contents and forces them toward the pelvic bones instead of toward the muscular floor. Accordingly, in this position, the bony pelvis is oriented so that forces are distributed to diminish the stress on the pelvic musculature. In summary, most of the load of the abdominal and pelvic viscera is supported by this bony articulation inferiorly (Fig. 2.4).

Anatomic Landmarks of the Bony Pelvis

The bones of the pelvis show some significant surgical landmarks that are important when the surgeon is operating inside the pelvis, including the ischial spine, coccyx, pubic arch, and pectineal line (Fig. 2.5).

Ischial Spine

The ischial spine is a sharp protuberance on the inner surface of the ischium that separates the greater from the lesser sciatic notch. The ischial spine is important clinically and anatomically because it can be palpated easily via the vagina and rectum or throughout the retropubic space and serves as a point of fixation for many structures that are important for pelvic organ support. The arcus tendineus levator ani inserts posteriorly on the ischial spine. Also, the ischial spine represents the lateral attachment site of the sacrospinous ligament.

Coccyx

The coccyx is the terminal portion of the sacrum and consists of four joined coccygeal vertebrae. It is palpable through the vagina and the rectum and is a valuable landmark surgically for many pelvic interventions.

Pubic Arch

The two pubic bones form an arch beneath the pubic symphysis. The pubic arch serves as the upper and lateral borders of the urogenital triangle, under which the distal urethra and vagina exit. The mean pubic arch angle is 70 to 75 degrees; however, a wide variability can be seen.

Pectineal Line

The edge along the superior, medial surface of the superior pubic rami is denominated the pectineal line. Anteriorly, this line is continuous with the pubic crest. Overlying the pectineal line is the Cooper ligament.

Pelvic Ligaments

Two main ligaments connect the pelvic bones to the sacrum and coccyx: the sacrotuberous ligament and the sacrospinous ligament. These ligaments also convert the two indentations on the pelvic bones in two exit areas on the lateral pelvic walls: the greater and lesser sciatic foramina (Fig. 2.6).

Sacrospinous Ligament

The sacrospinous ligament is a strong, triangular ligament; the high point of this ligament attaches to the ischial spine laterally, and the base joins to the distal sacrum and coccyx medially. This ligament divides the lateral pelvic outlet into two foramina: the greater sciatic foramen superiorly and the lesser sciatic foramen inferiorly. The coccygeus muscle is located on the superior surface of the sacrospinous ligament. The pudendal neurovascular package crosses behind the ischial spine and lateral aspect of the sacrospinous ligament as it exits the pelvis and enters the ischiorectal fossa. The S3 sacral nerve root and the pudendal nerve run over the superior margin of the sacrospinous ligament. The inferior gluteal artery, a branch of the posterior trunk of the internal iliac, is located close above the superior border of the sacrospinous ligament.

Sacrotuberous Ligament

The sacrotuberous ligament is also a triangular ligament. It has a broad base that extends from the posterior superior iliac spine...
along the lateral margin of the sacrum and coccyx. The apex of the ligament is attached to the medial margin of the ischial tuberosity. The sacrotuberous ligament forms the lateral-inferior border of the lesser sciatic foramen.

**Pelvic Muscles**

**Muscles of the Lateral Pelvis**

The obturator internus and piriformis are the muscles of the pelvic sidewalls.

**Obturator Internus Muscle**

The obturator internus muscle is found on the superior inner side of the obturator membrane. The obturator internus muscle originates from the inferior margin of the superior pubic ramus and from the pelvic surface of the obturator membrane. Its tendon exits the pelvis through the lesser sciatic foramen to insert onto the greater trochanter of the femur to laterally rotate the thigh. This muscle is innervated by the obturator internus nerve (L5–S2).
Anatomy and Principles of Surgery

Section 1

Piriformis Muscle

The piriformis muscle is part of the pelvic sidewall and is located posteriorly and lateral to the coccygeus muscle. It extends from the anterolateral sacrum to pass through the greater sciatic foramen and insert on the greater trochanter. Lying on top of the piriformis is a particularly large neurovascular plexus, the lumbosacral plexus.

Muscles of the Pelvic Floor

The skeletal muscles of the pelvic floor include the levator ani muscles and the coccygeus muscle. Both constitute the levator ani complex, called the levator platform when it is inserted in the midline.

Levator Ani Muscle Complex

The levator ani muscle complex is formed by several segments: the pubococcygeus, puborectalis, and iliococcygeus muscles. The urogenital hiatus is the space between the levator ani musculature through which the urethra, vagina, and rectum pass. Muscles of the pelvic floor, particularly the levator ani muscles, provide support to the pelvic visceral organs and play an integral role in urinary voiding, evacuation, and sexual function.

Arcus Tendineus Levator Ani

There is a linear thickening of the pelvic fascia covering the obturator internus muscle called the arcus tendineus levator ani. This thickened fascia forms a perceptible line from the ischial spine to the posterior surface of the superior pubic ramus in both sides. The muscles of the levator ani originate from this musculofascial attachment.

Puborectalis Muscle

The puborectalis muscle originates on the pubic bone, and its fibers pass posteriorly, forming a sling around the vagina, rectum, and perineal body. This results in the anorectal angle and promotes closure of the urogenital hiatus (Figs. 2.7–2.12).

Avascular Spaces

Owing to its embryologic development, the pelvis comprises a number of avascular spaces and connective tissue planes that allow the different viscera to function independently. These spaces are limited by some of the visceral branches of both hypogastric arteries. Commonly they contain blood vessels and nerves and are filled with lax areolar tissue, allowing blunt and easy dissection without rupture of these structures (Fig. 2.13).

The avascular spaces of the female pelvis include two lateral spaces (paravesical and pararectal) in both sides and four central spaces (space of Retzius or prevesical, vesicovaginal, rectovaginal, and presacral spaces) (Fig. 2.14).

Retropubic Space (Space of Retzius)

The retropubic space, also called the space of Retzius, is a virtual space between the bladder and the pubic bone. The pubic bone, the peritoneum, and the muscles of the anterior abdominal wall limit it. Its lateral borders are the arcus tendineus and the ischial spines. Within the retropubic space appears the dorsal clitoral neurovascular bundle, located in the midline, and the obturator neurovascular pack, located laterally as it enters the obturator canal. In some women, an accessory obturator artery arises from the external iliac artery and runs along the pubic bone. The space lateral to the bladder neck and urethra contains some nerves innervating the bladder and urethra, as well as the venous plexus of Santorini, that results in excessive bleeding if the proper dissection is not performed. The dissection of this space must be a blunt dissection close to the pubic bone, avoiding the clitoral neurovascular bundle. The dissection is facilitated with a full bladder, which outlines its boundaries very clearly. The median umbilical ligament or urachus can then be grasped with downward traction and transected with monopolar cautery to enter the retropubic space (Fig. 2.15).

Paravesical Spaces

The paravesical spaces are two lateral spaces that are localized anterior to the lateral parametria, lateral to the bladder, and lateral to the space of Retzius. Their margins are the superior vesical artery and bladder pillars medially; the external iliac vessels, obturator internus, and levator ani muscles laterally; the pubic bone anteriorly; and the lateral parametrium posteriorly. The paravesical space needs to be developed at the beginning for most pelvic radical procedures. Moreover, its dissection is
**FIG. 2.7** Sacrospinous and sacrotuberous ligaments delineate both greater and lesser sciatic foramina.

**FIG. 2.8** Muscles of the wall and floor of the pelvis.

**FIG. 2.9** Pelvic floor after supravelar anterior exenteration.

**FIG. 2.10** Pelvic floor after a total supravelar exenteration. Lateral view from the right side of the patient.
indispensable to identify the anterior aspect of the lateral parametria or cardinal ligament. After transection of the round ligament, the surgeon develops this space softly between the superior vesical artery medially and the external iliac vessels laterally and medially displaces the lateral aspect of the bladder.

**Pararectal Space**

The pararectal spaces are bilaterally located posterior to the lateral parametria or cardinal ligaments. The cardinal ligament defines the borders of the pararectal space anteriorly; the space is defined medially by the rectum, posteriorly by the sacrum, and laterally by the internal iliac artery or pelvic sidewall. The pararectal space must always be developed at the time of radical hysterectomy and pelvic exenteration. Opening the broad ligament parallel and lateral to the infundibulopelvic ligament permits access to this space. The displacement of the uterus medially helps to expose the pararectal space. The ureter must be identified, and it usually remains attached to the peritoneum of the posterior leaf of the broad ligament. Then the space between the ureter and the internal iliac artery is developed with meticulous blunt dissection, avoiding bleeding of small vessels in this area that could delay the dissection (Figs. 2.16 and 2.17).

**Vesicovaginal Space**

The vesicovaginal space is located in the midline. Its limits are the bladder anteriorly, the bladder pillars laterally, and the vagina posteriorly. The bladder pillars are composed of connective tissue and vessels, particularly small veins from the vesical plexus, and some cervical branches and contain the parametrial portion of the ureters. This plane is essential for the performance of any type of hysterectomy. To dissect the space, the surgeon should make a sharp incision in the midline between the bladder pillars; this incision will reveal a loose areolar avascular layer when in the proper plane. Misplacing the correct anatomic plane can result either in bleeding or in a bladder injury (Fig. 2.18).

**Rectovaginal Space**

The rectovaginal space separates the posterior vaginal wall from the rectum. It starts at the pelvic cul-de-sac and extends...
to the perineal body. It contains lax areolar tissue that can easily be dissected. Its lateral margins are the rectal pillars, which are part of the cardinal-uterosacral ligament complex connecting the rectum to the sacrum. Frequently, the surgeon may need to enter the rectovaginal space during a hysterectomy when the patient has unrecognizable anatomic features owing to an obliterated cul-de-sac from endometriosis or malignant disease. In that case, both ureters should be identified in advance, followed by identification of the rectum, to prevent any injury (Fig. 2.19).

**Presacral Space**

The presacral or retrorectal space is found between the rectum anteriorly and the sacrum posteriorly. This space is entered by dividing the peritoneum at the base of the mesentery of the sigmoid colon or through the pararectal spaces. Inferiorly this space terminates at the level of the levator muscles and laterally continues as the pararectal fossa. The middle sacral artery and a plexus of veins are attached superficial to the anterior longitudinal ligament of the sacrum. The endopelvic fascia in this space

---

**Fig. 2.15** The pelvic spaces as well as uterine ligaments are demonstrated in this drawing. (Modified from Peham H, Amreich J. Operative Gynecology. Philadelphia: JB Lippincott Company; 1934.)

**Fig. 2.16** The retropubic space, also called the space of Retzius, has been dissected. It is limited by the pubic bone, the peritoneum, and the muscles of the anterior abdominal wall. Its lateral borders are the arcus tendineus and the ischial spines.

**Fig. 2.17** The lateral parametrium is demonstrated by traction on the uterus. The paravesical space is located anterior to the right parametrium, and the pararectal space is located posterior to the right parametrium.

**Fig. 2.18** View during a radical hysterectomy of lateral pelvic spaces demonstrated on the right side of the pelvis. Anteriorly is the paravesical space, and posteriorly the pararectal space. In between both spaces, the lateral parametrium is seen.
envelops the visceral nerves of the superior hypogastric plexus and lymphatic vessels. The lateral boundaries of the presacral space are formed by the common iliac arteries, both ureters, and the sigmoidal branches of the inferior mesenteric artery (IMA) crossing on the left side.

The correct plane of dissection is between the rectum and the presacral fascia. Adequate development of this plane allows a radical extirpation en bloc of the rectum with the entire mesorectum, critical in rectal cancer; a mistaken dissection from the natural plane, invading the presacral fascia, may lead to injury of presacral veins, leading to significant bleeding (Fig. 2.20).

**Uterine Support Structures**

The structures that connect the cervix and vagina to the pelvic sidewall and sacrum are known as the cardinal and uterosacral ligaments, respectively or in conjunction, uterine parametria.

**Parametria**

The cardinal-uterosacral ligament complex suspends the uterus and upper vagina in their normal position. It serves to maintain vaginal length and keep the upper vaginal axis nearly horizontal in an erect woman so that the pelvic floor supports it. Absence of this support contributes to prolapse of the uterus and/or vaginal cuff. The cardinal ligaments are condensations of connective tissue that are several centimeters in width and run from the cervix and upper vagina to the pelvic sidewall. The uterine vessels run for much of their course within the cardinal ligaments.

The uterosacral ligaments are bands of connective tissue that are attached with the cardinal ligaments at their point of insertion in the cervix and upper vagina. The uterosacral ligaments pass posteriorly and inferiorly to attach to the ischial spine and sacrum.

The parametrium can be artificially divided into three bands of connective tissue: the posterior parametrium or uterosacral ligament, the cardinal ligament or lateral parametrium, and the cervicovesical ligament or anterior parametrium. The uterosacral ligaments are bands of connective tissue joining the cardinal ligaments at their point of insertion in the cervix. The uterosacral ligaments pass posteriorly and inferiorly to reach the ischial spine and sacrum. This ligament lies in close contact with the ureter before crossing the uterine artery within the lateral parametrium. The hypogastric nerve runs 1 to 2 cm inferior to the ureter and along the lateral aspect of the uterosacral ligament. The lateral parametrium contains the uterine artery and veins (superficial and deep) and some variable number of parametrial lymph nodes; in its deepest portion—close to the pelvic floor—appear the parasympathetic nerves (splanchnic nerves) coming from roots S2 to S4. Finally, the anterior parametrium, also known as the bladder pillar, includes the ureteric tunnel containing the ureter after crossing under the uterine artery (Figs. 2.21–2.23).

**Round Ligaments**

The round ligaments are expansions of the uterine musculature. They originate at the uterine fundus anteriorly and inferiorly to the fallopian tubes, run retroperitoneally through the broad ligament, and then enter the inguinal canal, terminating in the labia majora.

**Broad Ligament**

The broad ligament covers the lateral uterine corpus and upper cervix. The limits of the broad ligament are as follows: superiorly,
the round ligaments; posteriorly, the infundibulopelvic ligaments; and inferiorly, the cardinal and uterosacral ligaments. It consists of anterior and posterior leaves that separate to enclose viscera and blood vessels. Structures included within the broad ligament are considered retroperitoneal. Dissection between these sheets is necessary to provide retroperitoneal exposure of these structures. Various zones of the broad ligament are named for nearby structures such as the mesosalpinx (located near the fallopian tubes) and the mesovarium (located near the ovary). The broad ligament is composed of visceral and parietal peritoneum that contains smooth muscle and connective tissue.

**Pelvic Vasculature**

**Arterial Supply**

The aorta provides the blood supply to the pelvic structures. The aorta bifurcates at approximately the level of L4 to L5 into the right and left common iliac arteries. The common iliac arteries divide into the external iliac and internal iliac arteries; the internal iliac artery is also referred to as the hypogastric artery and provides most of the vascularization to the pelvic viscera and pelvic side wall and the gluteal muscles. The left common iliac vein travels anterior to the sacrum and medial to the aortic bifurcation and joins the right common iliac vein to form the vena cava under the right common iliac artery. The external iliac artery is located medial to the psoas muscle; it continues its course caudally to ultimately give off the femoral artery after crossing underneath the inguinal ligament. In the pelvis, the external iliac artery has few branches; these include the inferior epigastric artery and a variable superior vesical artery. The external iliac vein is much larger and lies posterior and medial to the artery. The external iliac vein also passes below the inguinal ligament before reaching the thigh.

The inferior epigastric vessels supply the rectus abdominis muscles. The inferior epigastric artery originates from the external iliac artery and travels through the transversalis fascia into a space between the rectus muscle and posterior sheath. In their course from the lateral position of the external iliac vessels, the inferior epigastric artery and vein run obliquely toward a more medial location as they approach the umbilicus. The superficial epigastric vessels originate from the femoral artery, perfuse the anterior abdominal wall, and branch extensively as they approach the umbilicus.

The hypogastric artery branches into anterior and posterior divisions. The posterior division runs toward the large sciatic notch, dividing into the lateral sacral, iliolumbar, and superior gluteal arteries. The anterior division of the internal iliac artery branches into the obliterated umbilical, uterine, superior vesical, obturator, vaginal, and inferior gluteal and internal pudendal arteries. The internal iliac vein lies medial to the internal iliac artery; the other veins travel with their corresponding arteries (Figs. 2.24–2.26).

To reach the perineum, the internal pudendal artery courses through the greater sciatic foramen, around the sacrospinous ligament, and back in through the lesser sciatic foramen. In this way the pudendal artery ends up below the pelvic diaphragm. Its branches supply the anal sphincter, the pelvic diaphragm, and the external genital structures in the female.

The internal iliac artery is a retroperitoneal structure; for any of its branches to be identified and accessed,
FIG. 2.25 Arterial vasculature of the pelvis.

FIG. 2.26 There are 9 division and 49 subdivision patterns of the internal iliac artery. The most constant arteries are superior vesical, uterine, internal pudendal, inferior gluteal, and superior gluteal.
a retroperitoneal dissection must be performed. The ureter should be identified before ligation of any lateral pelvic vessel. Most of the blood supply to the uterus, tubes, and ovaries derives from the uterine and ovarian arteries. The uterine arteries originate from the anterior division of the internal iliac arteries in the retroperitoneum. They usually share a common origin with the obliterated umbilical artery or superior vesical artery. The obliterated umbilical arteries, also known as superior vesical arteries and as lateral umbilical ligaments, are a useful landmark for the identification of the uterine artery. Simply pulling up the obliterated umbilical artery permits easy identification of the uterine artery. The uterine artery travels through the cardinal ligament over the ureter and approximately 1.5 cm lateral to the cervix. It then joins the uterus near the level of the internal cervical os, branching upward and downward toward the uterine corpus and inferiorly toward the cervix. The uterine corpus branches anastomose with vessels that derive from the ovarian arteries, thus providing collateral blood flow. The uterine artery also sends a branch to the cervicovaginal confluenence at the lateral aspect of the vagina. The vagina also receives its blood supply from this uterine branch, as well as from a vaginal branch of the internal iliac artery, which anastomoses along the lateral wall of the vagina. The ovarian arteries arise from the abdominal aorta. The right ovarian vein drains to the inferior vena cava (IVC), whereas the left ovarian vein drains to the left renal vein. The ovarian vessels travel through the infundibulopelvic ligaments in proximity to the ureter, along the medial aspect of the psoas muscle.

The ureter is supplied by small branches of the blood vessels it crosses: the common iliac, internal iliac, and superior and inferior vesical arteries. Above the pelvic brim the blood supply enters from the medial side; below the pelvic brim the blood supply to the ureter enters laterally. The blood supply to the bladder includes the superior and inferior vesical arteries, which are branches of the anterior trunk of the internal iliac artery. The blood supply to the rectum and anus consists of an anastomotic arcade of vessels from the superior rectal branch of the IMA and the middle and inferior rectal branches of the internal pudendal artery (see Figs. 2.24–2.26).

**Venous Drainage**

The IVC receives the venous flow from the right and common iliac veins and is located to the right of the aortic bifurcation. Similar to the arterial correspondents, the external iliac vein primarily drains the lower limbs, whereas the internal iliac vein drains the pelvic viscera, walls, gluteal region, and perineum. In most instances the major veins are mirror images of their arterial counterparts. However, the smaller vessels can vary from one individual to another. The inferior epigastric, deep circumflex iliac, and pubic veins are all pelvic tributaries of the external iliac vein. The external iliac vein is the upper continuation of the femoral vein. The nomenclature of the vessel changes at the mid-inguinal point, posterior to the inguinal ligament. The deep circumflex iliac vein crosses the anterior surface of the external iliac artery before entering the external iliac vein. Inferior to the entry point of the deep circumflex iliac vein, the inferior epigastric vein enters the external iliac vein cephalad to the inguinal ligament. The pubic vein forms a bridge between the obturator vein and the external iliac vein. On the left side, the external iliac vein is always medial to its corresponding artery. However, on the right side, it starts out in a medial position and gradually becomes posterior, as it gets closer to the point of fusion.

The internal iliac vein receives the middle rectal, obturator, lateral sacral, inferior gluteal, and superior gluteal veins as tributaries. The obturator vein enters the pelvis by way of the obturator foramen, where it takes a posterolateral route along the lateral pelvic wall, deep to its artery. In some instances the vessel is replaced by an enlarged pubic vein, which then joins the external iliac vein. The superior and inferior gluteal veins are accompanying veins of their corresponding arteries. The tributaries of the superior gluteal veins are named after the branches of the corresponding artery. They pass above piriformis and enter the pelvis via the greater sciatic foramen before joining the internal iliac vein as a single branch. The inferior gluteal veins form anastomoses with the first perforating vein and medial circumflex femoral vein before entering the pelvis via the greater sciatic foramen. The middle rectal vein is a product of the rectal venous plexus that drains the mesorectum and the rectum. It also receives tributaries from the bladder, as well as gender-specific tributaries from the prostate and seminal vesicle or the posterior wall of the vagina. It terminates in the internal iliac vein after travelling along the pelvic part of levator ani. Finally, the lateral sacral veins travel with their arteries before entering the internal iliac vein.

The internal and external iliac veins unite at the sacroiliac joint, on the right side of the fifth lumbar vertebra, to form the common iliac vein. The right common iliac vein is almost vertical and shorter than the left common iliac vein, which takes a more oblique course. The right obturator nerve crosses the right common iliac vein posteriorly; the sigmoid mesocolon and superior rectal vessels cross the left common iliac vein anteriorly. The internal pudendal vein drains to the internal iliac vein, whereas the median sacral veins drain into the common iliac vessels directly. The median sacral veins unite into a single vessel before entering the left common iliac vein. The internal pudendal veins receive inferior rectal veins and either clitoral and labial or penile bulb and scrotal veins before joining the common iliac vein (Figs. 2.27 and 2.28).

**Pelvic Lymphatic System**

The lymphatic drainage of the pelvis follows the vessels. The lymph nodes are located under the peritoneum adjacent to
the pelvic vasculature. The main groups of pelvic lymph nodes include the common iliac, external iliac, internal iliac, obturator, and presacral nodes. The presacral nodes, also known as medial sacral lymph nodes, run along the middle sacral artery in the presacral space. The common iliac nodal group consists of three subgroups: lateral, middle, and medial. The lateral subgroup is an extension of the lateral chain of external iliac nodes located lateral to the common iliac artery. The middle subgroup occupies the triangular area bordered by both common iliac arteries from the aortic bifurcation to the bifurcation of the common iliac artery into the external and internal iliac arteries. Nodes at the sacral promontory are included in this chain. The middle subgroup is located in the lumbosacral fossa and between the common iliac artery and common iliac vein.

The external iliac lymph nodes are located lateral to the external iliac artery and medial to the external iliac vein. They receive their lymphatic flow from the legs via the inguinal nodes and also from the pelvic viscera. The external iliac nodal group consists of three subgroups: lateral, middle, and medial. The lateral subgroup includes nodes that are located along the lateral aspect of the external iliac artery. The middle subgroup comprises nodes located between the external iliac artery and the external iliac vein. The medial subgroup contains nodes located medial and posterior to the external iliac vein. The medial subgroups are also known as the obturator nodes. The obturator lymph nodes are located in the obturator fossa, medial to the external iliac vessels and lateral to the obliterated umbilical ligament. The obturator nodes can be located by identifying the obturator nerve, which is usually the most easily visualized component of the obturator neurovascular bundle as it enters the obturator canal.

The internal iliac nodal group, also known as the hypogastric nodal group, consists of several nodal chains accompanying each of the visceral branches of the internal iliac artery. Among the nodes of this group, the connecting nodes are located at the junction between the internal and external iliac nodal groups. The internal iliac lymph nodes are located along the internal iliac vessels and are most numerous in the lateral pelvic side walls. In addition to the lymphatic drainage from the pelvic viscera, these nodes drain the pelvic viscera, the lower urinary tract, and gluteal region.

The uterine lymphatic flow also drains to the superficial inguinal lymph nodes along the round ligament, as well as to the presacral nodes along the uterosacral ligaments. Metastasis of uterine and cervical malignancies may occur in the superficial inguinal lymph nodes, as well as to the external and iliac nodes, and presacral nodes. The lymphatic drainage of the uterus and the upper two-thirds of the vagina flows through the obturator and internal and external iliac lymph nodes and ultimately drains into the common iliac lymph nodes. The lymphatic drainage of the ovaries travels with the ovarian vessels to the paraaortic lymph nodes. The distal one-third of the vagina, urethra, and vulvar lymphatic drainage goes to the inguinal nodes, reflecting their distinctly different embryologic origin compared with the upper genital tract.

Finally, the inguinal nodes appear outside the pelvis. This group consists of superficial inguinal and deep inguinal nodes. The superficial inguinal nodes, which are located in the subcutaneous tissue anterior to the inguinal ligament, accompany
the superficial femoral vein and the saphenous vein. The sentinel nodes for the superficial subgroup are those situated at the saphenofemoral junction, where the great saphenous vein drains into the common femoral vein. The deep inguinal nodes are those located along the common femoral vessels under the crural fascia. The anatomic landmarks that mark the boundary between the deep inguinal nodes and the medial chain of the external iliac nodes are the inguinal ligament and the origins of the inferior epigastric and circumflex iliac vessels (Fig. 2.29).

**Pelvic Nerves** (Fig. 2.30)

**Somatic Nerves**

Nerves crossing the pelvis are derived from the lumbar (T12–L5) and sacral plexuses (L4–S4) (Figs. 2.31 and 2.32). The lumbar and sacral plexuses are formed from the lumbar and sacral nerve roots, lateral to the intervertebral foramina. The lumbar plexus lies within the psoas muscle and forms the iliohypogastric and ilioinguinal nerves, the lateral cutaneous nerve of the thigh, and the genitofemoral nerve. They provide sensation to the inguinal region, mons pubis, upper vulva, and anterior upper thigh. The lumbar plexus has two major nerves of the lower extremity: the femoral and the obturator nerves (Figs. 2.33 and 2.34). The former emerges laterally to the psoas major, and the latter emerges medial to it. The femoral nerve runs alongside the psoas major and passes beneath the inguinal ligament, just lateral to the femoral artery. The femoral nerve is the major branch of the lumbar plexus, supplying sensory and motor function to the thigh. The obturator nerve runs just below the pelvic brim and enters the obturator canal.

The sacral plexus lies on the sacrum and piriformis muscle. It is formed by the anterior rami of sacral roots S1 to S4. In addition, it receives a contribution from L4 and L5, through the lumbosacral trunk (Fig. 2.35). The major branch of the sacral plexus, the sciatic nerve (L4–S3) (Fig. 2.36), exits the pelvis through the inferior portion of the greater sciatic foramen to innervate the muscles of the hip, pelvic diaphragm, vulva, perianal area, and lower leg. Almost all nerves arising from the sacral plexus go to the lower extremity. A main nerve of the sacral plexus is the pudendal nerve (S2–S4), which is the principal nerve of the vulva; it also involves the small motor nerves to the pelvic diaphragm. It arises from S2 to S4 just above the sacrospinous ligament and passes lateral to the ischial spine to reenter the pelvis through the greater foramen. Then it travels forward along the Alcock canal attached to the obturator internus muscle. Its branches supply the anal sphincter, the muscles of the urogenital diaphragm, and the external genitalia. A small branch or branches from S3 or S4 supply most of the levator ani muscle and the coccygeus muscle (Fig. 2.37).

**Autonomic Nerves**

The autonomic nerve supply to the pelvis runs through the superior hypogastric plexus, a ganglionic plexus that lies over
the bifurcation of the aorta in the presacral space (Fig. 2.38). The superior hypogastric plexus receives sympathetic input from the thoracic and lumbar splanchnic nerves and afferent pain input from the pelvic viscera (Fig. 2.39). Parasympathetic input, sometimes called the nervi erigentes, derives from S2 to S4 via the pelvic splanchnic nerves, which travel to join the hypogastric plexuses through the lateral pelvic wall, crossing the lateral parametrium in its deepest portion. From the superior hypogastric plexus, the splanchnic nerves split into two hypogastric nerves that run along the internal iliac vessels. These nerves connect to the inferior hypogastric plexus (Fig. 2.40). The inferior hypogastric plexus is located lateral to the pelvic viscera and consists of three areas: the vesical plexus, uterovaginal plexus, and middle rectal plexus. All these nerves, sympathetic and parasympathetic, are connected to a diffuse and extensive plexus of autonomic nerves called the pelvic plexus. The pelvic plexus lies within the fascia that covers this part of the pelvic wall and floor (Fig. 2.41).
Chapter 2 Abdominal and Pelvic Anatomy

Pelvic Viscera

Female Upper Genital Tract

The female upper genital tract consists of the cervix, uterine corpus, fallopian tubes, and ovaries. The uterus includes the corpus and cervix. In women of reproductive age, the corpus is twice the size of the cervix, whereas in prepubertal and postmenopausal woman they are of similar sizes. However, the dimension of the uterus may vary significantly depending on hormonal status, previous pregnancies, or the presence of uterine pathology. The corpus, or body, of the uterus has a triangular shape. The upper portion is called the fundus, and the inferior portion that is continuous with the cervix is named the isthmus, or lower uterine segment. There are no anatomic landmarks that divide these portions from the rest of the uterine corpus. The uterus is made up of three layers. The endometrium is the inner lining of the uterine cavity, with a superficial layer that consists of glandular epithelium and stroma. The thickness of the endometrium changes with the menstrual cycle or any other hormonal stimulation. The myometrium is the thickest layer of the uterus. It is composed of smooth muscle fibers that are oriented in different directions. Finally, the serosa is the thin external lining layer of the uterus, investing the body of the uterus, consisting of the visceral peritoneum. The cervix is a cylindrical structure that acts as the conduit between the endometrial cavity and the vagina. The superior portion is called the fundus, and the inferior portion that is continuous with the cervix is named the isthmus, or lower uterine segment. There are no anatomic landmarks that divide these portions from the rest of the uterine corpus. The uterus is made up of three layers. The endometrium is the inner lining of the uterine cavity, with a superficial layer that consists of glandular epithelium and stroma. The thickness of the endometrium changes with the menstrual cycle or any other hormonal stimulation. The myometrium is the thickest layer of the uterus. It is composed of smooth muscle fibers that are oriented in different directions. Finally, the serosa is the thin external lining layer of the uterus, investing the body of the uterus, consisting of the visceral peritoneum. The cervix is a cylindrical structure that acts as the conduit between the endometrial cavity and the vagina. The superior portion is continuous with the uterus. During hysterectomy, the junction between the uterine corpus and cervix can be located by palpating the area to feel the superior border of the cervix, which is tubular and firmer compared with the uterus. The inferior portion of the cervix projects into the vagina. In some women, because of special circumstances the cervix may appear flat with the vagina on examination rather than prominent. The cervical canal opens into the endometrial cavity at the internal orifice and into the vagina at the external os. The ectocervix is the surface of the cervix that can be visualized from the vagina. The cervix contains fibrous connective tissue mixed with smooth muscle located on the periphery that forms a continuous layer between the myometrium and the muscle in the vaginal wall. The endocervical canal is covered with glandular epithelium. This transforms into stratified squamous epithelium on the ectocervix owing to exposure to the acidic environment that is present in the vagina after menarche. The area where the epithelium changes from glandular to squamous is known as the transformation zone and is the area of the cervix that is most predisposed to dysplasia and malignant transformation.
FIG. 2.38 Lateral view of the pelvis showing the integration of arteries, veins, and nerves.

FIG. 2.39 The hypogastric plexus and pelvic plexus are shown along with both pelvic autonomic nerves.

FIG. 2.40 The parasympathetic roots connect with the pelvic nerve to form the pelvic plexus.

FIG. 2.41 Global view of the pelvic autonomous innervation.
The uterine adnexa consist of the ovaries and fallopian tubes. The ovaries are attached to the uterus laterally and/or posteriorly, depending on the position of the patient. The connecting structures of the ovaries include the utero-ovarian ligament, which attaches the ovary to the uterus; the infundibulopelvic ligament, which contains the ovarian vessels and joins the ovary to the retroperitoneum; and the part of the broad ligament that forms the mesovarium. The ovary consists of an external cortex, where the oocytes and follicles are located, and the central stroma, where the blood vessels and connective tissue create a fibromuscular tissue layer. The fallopian tubes arise from the uterine corpus posterior and superior to the round ligaments. The broad ligaments support the tubes with a progressive thickening of connective tissue called the mesosalpinx. Frequently, paratubal cysts appear within the mesosalpinx; these are fragments of the embryologic ducts that form and then disappear during embryologic development. The fallopian tube connects the uterine and abdominal cavities. Each tube is divided into four different portions: the interstitial portion, where the tube passes through the uterine cornua; the isthmus, with a narrow lumen and thick muscular wall; the ampulla, with a larger lumen and mucosal folds; and finally the fimbria, located at the end of the tube, with leaflike protrusions that increase the surface area on the distal part of the tubes to facilitate interaction with the oocyte. The fallopian tubes consist of an outer muscularis layer of the tube with longitudinal smooth muscle fibers and an inner layer with circular fibers. The fallopian tube mucosa is composed of numerous delicate papillae consisting of three cell types: ciliated columnar cells; nonciliated columnar secretory cells; and intercalated cells, which may simply represent inactive secretory cells.

**Bladder**

The bladder is located in the midline of the pelvis, just posterior to the pubic bone. The bladder is separated from the pubic bone by a virtual plane, called the retropubic space or the space of Retzius, which contains the venous plexus of Santorini. The borders of the bladder include the pubic symphysis anteriorly, the pelvic side walls on both sides, and the lower uterine segment and vagina posteriorly. The inferior boundary of the bladder is the lower uterine segment and anterior cervix. The superior border of the bladder is in contact with the obliterated umbilical arteries laterally and in the midline with the urachus. In the fetus, the urachus connects the developing bladder to the umbilicus. After delivery the urachus becomes the median umbilical ligament, which joins the apex of the bladder to the anterior abdominal wall. The upper part of the bladder is covered by the parietal peritoneum of the anterior abdominal wall. Inferiorly, the peritoneum reaches the vesicouterine fold. The rest of the bladder is located retroperitoneally. The bladder is very distensible. When empty, the bladder orients the apex toward the pubic bone. When full, the bladder is globular, with normal capacities ranging from 400 to 500 mL. When the bladder is expanded, the musculature of the dome can become thin. Consequently, before a pelvic surgical procedure is initiated, decompression of the bladder with a bladder catheter can help avoid injury. The regions of the bladder include the dome superiorly and the base inferiorly. The base of the bladder lies directly on the anterior vaginal wall and consists of the trigone and detrusor loop, a thickening of the detrusor muscle, the thickness of which does not vary with filling of the bladder. The bladder trigone is a triangular area at the base of the bladder bounded by the internal urethral meatus and the two ureteric orifices. The ureteric orifices and the internal urethral meatus form a triangle of 3 cm per side.

Histologically, three layers line the bladder: mucosa, muscle, and adventitia. The bladder mucosa consists of a transitional cell epithelium and underlying lamina propria and is also known as the urothelium. The muscular layer, or the detrusor muscle, consists of interlacing bundles of smooth muscle. This plexiform organization of detrusor muscle bundles is ideally suited to reduce all dimensions of the bladder lumen on contraction. The outer adventitial layer primarily consists of adipose tissue and loose connective tissue. The blood supply to the bladder includes the superior and inferior vesical arteries, which are branches of the anterior trunk of the internal iliac artery. Bladder innervation is provided by the parasympathetic and sympathetic autonomic fibers of the pelvic and hypogastric nerve plexuses, respectively.

**Ureters**

The ureters are retroperitoneal structures that run from the renal pelvis to the bladder. They are approximately 25 to 30 cm in length from the renal pelvis to the trigone of the bladder. The pelvic brim divides them into abdominal and pelvic segments, each of which is approximately 12 to 15 cm in length (Fig. 2.42). The pelvic ureters can be injured during pelvic surgery. The ureters enter the pelvis at the pelvic brim, where they cross from lateral to medial, as well as anterior to the bifurcation of the common iliac arteries. The ureters enter the pelvis very close to the ovarian vessels; therefore identification of the ureter is imperative before an adnexectomy is performed. The ureter usually lies first medial and deeper to the infundibulopelvic ligament, so typically it may be necessary to open the retroperitoneal space lateral to the infundibulopelvic ligament and create a window between the ovarian vessels and the ureter to safely secure the ovarian vascular pedicle. The ureters then descend into the pelvis within a
peritoneal cover attached to the medial leaf of the uterine broad ligament and the lateral pelvic side wall. At the level of the uterus, the ureter descends along the lateral side of the uterosacral ligament. It then passes under the uterine arteries, entering the ureteric tunnel and crossing the anterior parametrium in the upper portion of the vagina. The ureters enter the posterior aspect of the bladder and run obliquely through the bladder wall for 1.5 cm before terminating in the trigone (Fig. 2.43). The ureter is supplied by the blood vessels it crosses—the ovarian, internal iliac, superior vesical, and inferior vesical arteries. Above the pelvic brim the blood supply enters from the medial side; below the pelvic brim, the blood supply enters laterally.

**Sigmoid Colon, Rectum, and Anus**
The sigmoid colon enters the pelvis from the descending colon slightly to the left of the midline and is basically an extraperitoneal organ. Its blood supply derives from the sigmoid arteries, branches of the IMA. Once the sigmoid colon has descended into the pelvis, its course straightens. It enters the retroperitoneum at the pelvic posterior cul-de-sac and becomes the rectum. Then it gets wider, forming the rectal ampulla, an area of final storage, and turns downward to almost a 90-degree angle to become the anus. The rectum and anus rest on the sacrum and levator ani muscles, and the vagina lies anterior to the rectum, separated from it by the rectovaginal septum. The blood supply to the rectum and anus consists of an anastomotic arcade of vessels from the superior hemorrhoidal branch of the IMA, and the middle and inferior hemorrhoidal branches of the internal and pudendal artery, respectively. The anus is surrounded by the internal anal sphincter and external anal sphincter. The internal anal sphincter consists of a thicker layer of the circular involuntary smooth muscle fibers, which provides 80% of the latent tone of the sphincter. The external anal sphincter consists of skeletal muscle fibers and is attached to the coccyx (Fig. 2.44).

**Perineum**
The area localized between the vagina and anus is typically referred to as the perineum; nevertheless, from the strictly anatomic point of view, the perineum is the anatomic territory that includes the pelvic outlet inferior to the pelvic floor. The area between the vagina and anus is more properly called the perineal body. The limits of the anatomic female perineum are the ischiococcygeal rami, ischial tuberosities, sacrotuberous ligaments, and coccyx. A virtual line linking the ischial tuberosities divides the perineum into the urogenital triangle above and the anal triangle below. It is remarkable that in the standing position the urogenital triangle is oriented horizontally and the anal triangle is inclined upward so that it faces more posteriorly.

**Perineal Membrane**
The perineal membrane is a dense fibrotic layer situated over the urogenital triangle. Laterally, it is inserted in the pubic arch and has a free posterior margin anchored in the midline by the perineal body. The urethra and vagina cross throughout the urogenital hiatus in the perineal membrane to exit at the introitus. The perineal membrane, therefore, offers the anatomic support of the distal urethra, distal vagina, and perineal body to be connected to the lateral pubic arches.

**Urogenital Triangle**
The urogenital triangle is divided into a superficial and a deep perineal area. The superficial perineal space contains the superficial perineal muscles including the ischiocavernosus and the superficial transverse perineal muscles, the erectile tissue of the clitoris, the vestibular bulbs, and the Bartholin glands. The deep perineal space lies just beneath the perineal membrane and inferior to the levator ani muscles. Within the deep perineal space lie the external urethral sphincter and the urethrovaginalis, and the deep transverse perineal muscles (Fig. 2.45).

**Perineal Body**
The perineal body is the point of junction of the superficial and deep transverse perineal muscles, perineal membrane, external anal sphincter, posterior vaginal muscularis, and fibers from the puborectalis and pubococcygeus muscles. The perineal body plays an important role in support of the vagina and in normal
anal function. The pudendal neurovascular trunk provides the vascular and nerve supply to the perineum, including the deep and superficial perineal spaces.

**Anal Triangle**
The anal triangle is formed on both sides by the internal margins of the sacrotuberous ligaments, anteriorly by the superior edge of the perineal membrane and perineal body, and inferiorly by the coccyx. The superior roof of the anal triangle is the levator ani muscle. The anal canal and anal sphincter muscles are situated in the middle of the anal triangle. Lateral to the anal sphincter complex on each side is the ischiorectal fossa.

**Ischiorectal Fossa**
The ischiorectal fossa is the space under the levator ani muscles and over to the perineum.

**Vulva**
The female external genitalia or vulva includes the labia majora, labia minora, clitoris, vulvar vestibule, external urethral meatus, and vaginal orifice. The labia minora split anteriorly to form medial and lateral folds. The lateral folds join superiorly over the clitoris to form the clitoral hood. The labia minora blend posterior to the vestibule to form the posterior fourchette. The labia majora are lateral to the labia minora and unite anteriorly to form the mons pubis. The mons pubis is a fat pad that overlies the inferior aspect of the pubic symphysis. The vulvar vestibule is the area encircled by the labia minora into which the urethra and vagina exit in the perineum. The hymen is a ring-shaped membrane that surrounds the vaginal orifice and typically has one or more central perforations. Within the vestibule, the outlets of the Skene glands appear on each side of the lateral margin of the urethra. Similarly, the exits of the Bartholin glands are found on the posterior lateral margin of the vagina, distal to the hymen insertion (Figs. 2.47–2.49).

**Vagina**
The vagina is a fibromuscular cylindrical cavity with a great distensible capacity; it is covered with rugal mucosal folds that extend from the vestibule to the uterine cervix. The longitudinal shape of the vagina resembles a trapezoid, narrowest at the introitus and becoming progressively wider as it approaches the vaginal apex and cervix. In the transverse plane, the vagina has a boxlike configuration at its distal end (toward the introitus) and is flattened proximally. In the sagittal plane, the vagina has a distinct angulation. The upper two-thirds of the vagina angles toward the third and fourth sacral vertebrae and is almost horizontal in the erect woman. The lower one-third is almost vertical as it crosses through the perineal membrane to the vestibule.
Urethra

At 2 to 3 cm in length and 6 to 7 mm in diameter, the female urethra joins the bladder to the vestibule and is responsible for urinary continence. Its connection to the bladder is called the bladder neck. The urethra then continues its course attached to the vagina for its distal part and terminates at the external meatus at the level of the vaginal introitus. The female urethra bends as it crosses down from the bladder within the perineal membrane to the vestibule. Histologically, the urethra has four distinct layers: mucosa, submucosa, internal urethral sphincter muscle, and striated external urethral sphincter muscle. The vascular supply of the urethra originates from branches of the pudendal vessels and the vesical vessels. The internal urethral sphincter is primarily formed of smooth muscle fibers. The precise function of this smooth muscle is not well understood, although it has been suggested that these fibers work along the striated urethral sphincter muscle to improve the efficiency of the sphincter mechanism. The striated muscle component of the sphincter includes the external urethral sphincter, the compressor urethrae, and the urethrovaginalis muscle. These three muscles form a single unit: the skeletal urogenital sphincter.

This sphincter unit measures nearly 2.5 cm in length and encircles the urethra in its midportion from just below the bladder neck to the perineal membrane within the deep perineal space. The smooth muscle portion of the urethra receives innervation from the autonomic nerves of the pelvic plexus, whereas the striated urethral sphincter is innervated by branches of the pudendal nerve.

Normal urethral function depends not only on the intrinsic sphincter mechanism but also on the anatomic urethral support. The urethra lies on a hammocklike supportive layer composed of periurethral endopelvic fascia and anterior vaginal wall. Debilitation of these supportive structures leads to inefficient sphincter function resulting in stress incontinence.

The Retroperitoneum

From the anatomic perspective, the retroperitoneum or retroperitoneal space is the area of the posterior abdomen located between the posterior parietal peritoneum and the posterior part of the fascia transversalis. Within this space a number of retroperitoneal viscera can be located, such as the adrenal glands, both kidneys, and the ureters. Very important neurovascular and lymphatic structures run within the retroperitoneal space, including the aorta and its abdominal branches, the inferior vena cava (IVC) and its tributaries, the lymphatic vessels and the lymph nodes, and the lumbar plexus with its branches and the paravertebral sympathetic trunk. The visceral peritoneum covers in continuity the walls of the abdominal cavity. In contrast to the visceral peritoneum, the parietal peritoneum can be easily dissected and removed because it is usually softly attached...
**Abdominal Aorta**

The abdominal aorta begins at the aortic hiatus of the diaphragm, anterior to and at the level of the lower portion of the 12th thoracic vertebra, descending slightly lateral to the midline and in close relation to the vertebral bodies, ending at the fourth lumbar vertebra. At that point, it bifurcates into two common iliac arteries. The aorta is in contact with the celiac plexus and the lesser sac or omental bursa anteriorly, and the pancreatic body with the splenic vein attached posteriorly. Behind the pancreas, between the superior mesenteric artery (SMA) and the aorta, is the left renal vein, crossing over the anterior wall of the aorta.

Beneath the pancreas the aorta is in contact with the horizontal part of the duodenum. Upward and laterally on the right, the aorta is in contact with the cisterna chyli, thoracic duct, azygos vein, and right crus of the diaphragm, which separates it from the IVC. Laterally on the left, the aorta is in contact with the crus of the diaphragm and celiac ganglion. At the level of the second lumbar vertebra, there is contact with the duodenojejunal flexure and sympathetic trunk, ascending duodenum, and inferior mesenteric vessels. Below the second lumbar vertebra the aorta is in contact with the IVC. The bifurcation of the abdominal aorta is projected on the abdominal wall surface at the level of the umbilicus.

**Branches of the Abdominal Aorta**

**Ventral**—Celiac trunk, SMA, and IMA

**Lateral**—Inferior phrenic arteries, middle suprarenal arteries, renal arteries, and gonadal arteries

**Dorsal**—Lumbar and median sacral arteries

**Terminal**—Common iliac arteries

**Ventral Branches**

**Celiac Trunk.** The celiac trunk is the first wide ventral branch of the aorta, 1.5 cm long, arising just below the aortic diaphragmatic hiatus. It is generally horizontal and oriented forward but may be caudally or cranially oriented. In approximately 50% of the population, the celiac trunk follows the standard pattern, giving off three branches: the left gastric artery, the splenic artery, and the common hepatic artery. Frequently, the inferior phrenic arteries also arise from the celiac trunk either as a single trunk or separately.

**Superior Mesenteric Artery.** The SMA is the second ventral branch of the abdominal aorta. This artery supplies all of the small intestine, the right colon, and most of the transverse colon. The origin of the SMA is about 1 cm below the origin of the celiac trunk, behind the pancreas, and is crossed anteriorly by the splenic vein. The left renal vein crosses right behind the first centimeters of the SMA, followed by the uncinate process of the pancreas and the horizontal part of the duodenum.

**Inferior Mesenteric Artery.** The IMA supplies the left third of the transverse colon, the descending colon, the sigmoid colon, and part of the rectum. It arises a few centimeters from the aortic bifurcation and is much smaller in diameter than the SMA. It follows a retroperitoneal path in the left colonic branches and enters the sigmoid mesocolon with the rectal arteries (Fig. 2.53).

**Lateral Branches**

**Inferior Phrenic Arteries.** The inferior phrenic arteries may arise together as a trunk or separately as independent vessels, just above or at the origin of the celiac trunk. These

---

**Retroperitoneal Vasculature**

Two large vessels cross the retroperitoneal midline over the spinal column: the abdominal aorta and the inferior cava. The aorta gives off branches for arterial supply to most of the intraperitoneal viscera and both lower limbs. Similarly, the IVC receives tributaries from the whole abdomen and lower extremities (Fig. 2.52).
Inferior phrenic arteries

FIG. 2.51 Global view of the retroperitoneum after removing all abdominal and retroperitoneal organs. The posterior muscular boundaries and the main retroperitoneal vessels can be identified.

FIG. 2.52 Both major vessels of the abdomen, the aorta and vena cava, are shown from their openings in the diaphragm down to their main division in the pelvis.
arteries ascend along the diaphragmatic crura. Branches of the inferior phrenic artery reach the thoracic wall and anastomose with the posterior intercostal and musculophrenic arteries. Other branches supply the upper portion of the adrenal glands, as well as the Glisson capsule of the liver through anastomoses at the bare area within the triangular ligaments.

**Middle Suprarenal Arteries.** The middle suprarenal arteries are small arteries that arise laterally to the aorta, at about the same level as the origin of the SMA. They reach the adrenal glands and anastomose with the superior phrenic and inferior suprarenal arteries originating from the renal artery.

**Renal Arteries.** The renal arteries arise on each side of the vertebral column between the first and second lumbar vertebra, below the origin of the SMA. The renal artery usually has an oblique cranial-caudal course; after giving off the inferior suprarenal artery, the renal artery divides into an anterior and a posterior branch. The origin of the left renal artery is higher than that of the right. Anatomic variants of the renal blood supply occur commonly (Figs. 2.54 and 2.55).

**Gonadal Arteries.** The gonadal arteries arise anterolaterally from the abdominal aorta, a few centimeters below the renal arteries. The ovarian arteries follow a descending path, anterior to the IVC and parallel to the ovarian veins, anterior to the ureter on the right, and posterior to the left ovarian vein at its origin, but anterior to the left ureter. The gonadal artery may arise from an inferior polar renal artery and send branches to the ureter and also from the lumbar, adrenal, or iliac arteries. Unlike the testicular arteries, which cross the inguinal canal, in the female the ovarian arteries follow a different path in the pelvis to supply the ovaries, reaching the broad ligament. Some branches of the gonadal artery supply the ureters and the uterine tubes and anastomose with the uterine artery (Fig. 2.56).

**Dorsal Branches**

**Lumbar Arteries.** There are usually four lumbar arteries on each side, arising from the posterior aspect of the abdominal aorta. They are the equivalent of the intercostal arteries in the abdomen. These arteries follow a posterior path over the lumbar vertebral bodies, continuing in the posterior abdominal wall.
They anastomose among them with others as the subcostal, iliolumbar, deep circumflex iliac, and inferior epigastric arteries (Fig. 2.57A–B).

**Median Sacral Artery.** The median sacral artery is a small posterior branch of the abdominal aorta, arising from the aorta above its bifurcation, that descends in the midline, anterior to the fourth and fifth lumbar vertebrae, the sacrum and coccyx. There are anastomoses with the rectum, lumbar branches of the iliolumbar artery, and lateral sacral arteries.

**Terminal Branches**

**Common Iliac Arteries.** The abdominal aorta bifurcates at the level of the fourth lumbar vertebra into the right and left common iliac arteries, which supply the pelvis and lower extremities. The common iliac arteries divide into the external iliac artery, which courses parallel to the axis of the common iliac artery, and the internal iliac artery, which is a posteromedial branch. As described earlier, the common iliac arteries give branches to the surrounding tissues, peritoneum, psoas muscle, ureter, and nerves.

**Inferior Vena Cava**

The IVC receives blood from all the structures and abdominal viscera below the diaphragm, being formed by the convergence of the common iliac veins. It follows an ascending direction in front of the lumbar vertebrae to the right of the abdominal aorta. The IVC reaches the liver and has an intrahepatic portion, which may be totally surrounded by hepatic parenchyma (Fig. 2.58). It ends in the right atrium of the heart, through the tendon of the diaphragm. Where it enters the inferoposterior part of the right atrium, there is a semilunar valve to prevent reflux.

**Variations**

A number of variants may be found. For instance, the IVC may appear as a double vena cava owing to a failure of interconnection between the common iliac veins. It may also be located to the left of the aorta.

**Collateral Circulation**

There is a rich collateral venous system circumventing the IVC in case of thrombosis or occlusion, through either a superficial or a deep venous network. The superficial system includes the epiigastric, circumflex iliac, lateral thoracic, thoracoepigastric, internal thoracic, posterior intercostal, external pudendal, and lumbovertebral anastomotic veins. The deep system includes the azygos, hemiazygos, and lumbar veins. The vertebral venous plexus is also in the collateral venous system.

---

**Fig. 2.57** (A) Two left lumbar veins and one right lumbar artery are seen within the intercavoaortic space. (B) Over the anterior spinal ligament, lumbar arteries and veins cross the interaortocaval space. (C) A second left lumbar vein, frequently called the lumboazygous, drains into the left renal vein. IMA, Inferior mesenteric artery.
Tributaries of the Inferior Vena Cava

Lumbar Veins. There are typically four pairs of lumbar veins, which drain the lumbar muscles and skin from the abdominal wall. The lumbar veins also drain the vertebral venous plexuses and are connected by the ascending lumbar veins. The first and second lumbar veins may anastomose with the ascending lumbar veins or the lumbar azygos vein (see Fig. 2.57).

Ascending Lumbar Veins. The ascending lumbar veins originate from the common iliac veins and establish connections between the common iliac and iliolumbar and lumbar veins. They ascend behind the psoas muscle and in front of the lumbar vertebrae. Upward, they join the subcostal veins; turning medially, they form the azygos vein on the right and the hemiazygos vein on the left.

Ovarian Veins. There is a venous plexus in the broad ligament of the uterus. This plexus communicates with the uterine plexus, from which originate the two ovarian veins in each side, running along with the ovarian artery and coursing together on each side of the artery, draining via the IVC on the right and via the left renal vein on the left. All these veins have valves, and their incompetence may lead to pelvic varicosities (see Fig. 2.56).

Renal Veins. In contrast to the arteries, there is free circulation throughout the venous system, and therefore the veins do not have a segmental model. Even though there is usually one renal vein per kidney, it receives blood from four intrarenal veins: The anterior branch receives blood from the anterior portion of the kidney, and the posterior branch receives blood from the posterior portion. Because the IVC is on the right side, the left renal vein is typically the longer of the two. The left renal vein often receives blood from the following left-sided veins: inferior phrenic, suprarenal, gonadal, and second lumbar. Inversely, on the right side these veins drain directly into the IVC. Often, each renal vein receives blood from a ureteral vein.

Variations. Sometimes the left renal vein passes behind the abdominal aorta and is called a retroaortic left renal vein. When the left renal vein splits in front of and behind the aorta, it is named a circumaortic renal vein (Fig. 2.59).

Suprarenal Veins. There is only one vein for each adrenal hilum. The right adrenal vein is short and small and opens directly and horizontally into the lateroposterior aspect of the IVC, far above the right renal vein. The left adrenal vein is longer and larger and descends from the adrenal gland posteriorly to the body of the pancreas to open into the left renal vein, joined by a branch of the left inferior phrenic vein, about 1 cm from the IVC.
**Inferior Phrenic Veins.** The inferior phrenic veins follow the same distribution as that of the phrenic arteries on the lower diaphragmatic surface. The right inferior phrenic vein ends in the IVC, above or together with the right suprahepatic vein. The left vein is frequently double, with one branch draining in the IVC or together with the left suprahepatic vein.

**Lymphatic System**

The retroperitoneal lymph nodes form a rich and extensive chain from the inguinal ligament to the posterior mediastinal nodes. They are classified by the vessels to which they are adjacent. Therefore all the nodes located over the aorta include the following groups: celiac axis, SMA, and IMA. In addition, there are paraaortic nodes, on the right and left sides of the vessel. Consequently, the nodes surrounding the vena cava are called precaval, retrocaval, and laterocaval nodes. The celiac nodes are located near the base of the celiac artery and its branches. They are closely related to the celiac ganglion and the lymph nodes of the SMA. These nodes receive lymph from the stomach, liver, pancreas, and superior mesenteric nodes. Mesenteric nodes receive lymph from the small bowel, right colon, part of the transverse colon, and pancreas. They communicate with the celiac and the inferior mesenteric nodes. The IMA nodes receive lymph from the left colon. The right paraaortic nodes, along with the left paraaortic nodes, form the right lumbar chain of nodes, which may be found around the IVC. The left paraaortic (left lumbar) lymph nodes communicate with the common iliac nodes and drain into the thoracic duct. These nodes have a high clinical and surgical relevance, especially those located under the left renal vein. The left infrarenal paraaortic nodes are typically the target of many ovarian neoplasms and other pelvic malignancies, even in circumstances when pelvic nodes are not involved. The caval group of nodes includes precaval, retrocaval, and paracaval nodes. Precaval lymph nodes are located on the anterior wall of the IVC. Two of these nodes, one at the aortic bifurcation and the other below the left renal vein, are fairly constant. Retrocaval lymph nodes are located on the psoas muscle and the right crus of the diaphragm. The right paracaval nodes are found on the right lateral side of the IVC. The nodes located at the entrance of the right renal vein into the IVC are the metastatic nodes for right ovarian tumors (Fig. 2.60A–B).

The pelvic lymphatic system, including the common iliac, external and internal iliac, obturator, and sacral nodes, was discussed earlier. The pelvic group of lymph nodes is frequently the site of metastases from gynecologic malignancies. Because these nodes receive lymphatic flow from both groins, they may receive metastatic cells from the inguinal nodes. The pelvic and the aorto caval nodes are extensively connected, but occasionally a tumor will metastasize directly to the paraaortic area through the lymphatics surrounding the gonadal vessels. The number of paraaortic nodal metastases from pelvic tumors is higher in the left paraaortic area as a consequence of a higher lymphatic flow and connection between that anatomic group and the pelvic organs.

**Retroperitoneal Nerves**

Six major nerves are present in the retroperitoneal space: iliohypogastric, ilioinguinal, genitofemoral, lateral femoral cutaneous, obturator, and femoral. All these are the branches of the lumbar plexus (as previously shown in Fig. 2.31), which is formed by anterior rami from T12 to L4. In addition, the sympathetic chain runs on either side of the vertebral column. The iliohypogastric nerve (T12–L1) is the first nerve of the lumbar plexus. It emerges from the lateral border of the psoas muscle. After crossing the quadratus lumborum muscle, it travels downward between the internal oblique and the transversus abdominis muscles. The iliohypogastric nerve produces two branches. The lateral cutaneous nerve supplies the...
posterolateral skin of the gluteal area, and the anterior cutaneous nerve supplies the skin over the symphysis pubis. The ilioinguinal nerve (L1) has the same general route as the iliohypogastric nerve and enters the inguinal canal. In the thigh, it innervates the skin over the triangle of Scarpa. The genitofemoral nerve (L1–L2) crosses the psoas muscle anteriorly. It gives origin to two branches: the genital and femoral branches (Fig. 2.61). The genital branch passes through the deep inguinal ring and enters the inguinal canal. In women, the genital branch accompanies the round ligament, innervating the skin of the mons pubis and labia majora. The femoral branch passes below the inguinal ligament and participates in the innervation of the skin of the triangle of Scarpa. The lateral femoral cutaneous nerve (L2–L3) emerges from the lateral border of the psoas muscle approximately at the area of the fourth lumbar vertebra. After perforating the inguinal ligament close to the superoanterior iliac spine, it passes into the lateral aspect of the thigh. The obturator nerve (L2–L4) emerges from the medial border of the psoas muscle. It enters together with the obturator vessels into the obturator foramen, continuing downward to innervate the medial part of the thigh. The femoral nerve (L2–L4) emerges from the lateral border of the psoas muscle. It passes under the inguinal ligament lateral to the femoral artery. The lumbar sympathetic chain lies right and left, along the medial border of the psoas muscle (Fig. 2.62). It is located anterior to the lumbar vertebrae and is covered by the IVC on the right and the right paraaortic nodes on the left. It is formed by four ganglia, which vary in size and position. They communicate with one another and with the thoracic trunk above and the pelvic trunk below.

**Adrenal Glands**

The suprarenal glands, also known as adrenal glands, belong to the endocrine system. They are a pair of triangular glands, each about 2 inches long and 1 inch wide, located on top of the kidneys. The suprarenal glands are responsible for the release of hormones that regulate metabolism, immune system function, and the salt–water balance in the bloodstream; they also aid in the body's response to stress. Each adrenal gland, together with the associated kidney, is enclosed in the renal fascia of Gerota and surrounded by fat. The glands are firmly attached to the fascia, which is in turn attached firmly to the abdominal wall and the diaphragm. A layer of loose connective tissue separates the capsule of the adrenal gland from that of the kidney. Because the kidney and the adrenal gland are thus separated, the kidney can be ectopic without a corresponding displacement of the gland. Fusion of the kidneys, however, is often accompanied by fusion of the adrenal glands. Occasionally the adrenal gland is fused with the kidney so that separation is almost impossible. If individuals with such a fusion need a partial or total nephrectomy, they also require a coincidental adrenalectomy. The medial borders of the right and left adrenal glands are about 4.5 cm apart. In this space, from right to left, are the IVC, the right crus of the diaphragm, part of the celiac ganglion, the celiac trunk, the SMA, and the left crus of the diaphragm (Fig. 2.63).
Arterial Supply
The arterial supply of the adrenal glands arises, in most cases, from three sources:
- The superior adrenal arteries arise from the inferior phrenic arteries.
- The middle adrenal artery arises from the aorta just proximal to the origin of the renal artery. It can be single, multiple, or absent. One or more inferior adrenal arteries arise from the renal artery.
- The accessory renal artery, or superior polar artery, is the third source.

Venous Drainage
The adrenal venous drainage does not accompany the arterial supply and is much simpler. A single vein drains the adrenal gland, emerging at the hilum. The left adrenal vein passes downward over the anterior surface of the left adrenal gland (Fig. 2.64). The left inferior phrenic vein joins this vein before entering the left renal vein. From the right adrenal gland, the right adrenal vein passes obliquely to drain into the IVC posteriorly.

Occasionally an adrenal gland has two veins—one following a normal course and the other being an accessory vein that enters the inferior phrenic vein. When the posterior approach to the adrenal gland is used, the left adrenal vein is found on the anterior surface of the gland. The right adrenal vein is found between the IVC and the gland. Careful mobilization of the gland is necessary for adequate ligation of the vein. Consider that adrenal glands have one of the greatest amounts of vascularization per gram of tissue within the body.

Lymphatic Drainage
The lymphatics of the adrenal gland are profuse owing to a subcapsular plexus. Drainage is to the renal hilar nodes, lateral aortic nodes, and nodes of the posterior mediastinum above the diaphragm by way of the diaphragmatic orifices for the splanchic nerves. Lymphatics from the upper pole of the right adrenal gland may enter the liver. The majority of capsular lymphatic vessels pass directly to the thoracic duct without the intervention of lymph nodes.

Kidneys
The kidneys are two brownish solid organs situated on each side of the midline in the retroperitoneal space. Their weight depends on body size, averaging 150 and 135 g each in men and women, respectively. Kidneys in adults vary in length from 11 to 14 cm, in width from 5 to 7 cm, and in thickness from 2.5 to 3.0 cm. Because of the effect of the liver, the right kidney is shorter and broader and lies 1 to 2 cm lower than the left kidney.

Gerota Fascia
A layer of perirenal fat surrounds each kidney. This fat is encapsulated by the Gerota fascia. This fascia is completely fused above and lateral to the kidney; however, medially and inferiorly this fusion is incomplete. This partial fusion is clinically important for controlling the possible courses of metastases, bleeding, or infection around the kidneys. The layers of the Gerota fascia stretch in the midline, with the posterior layer crossing below the great vessels and the anterior layer extending over the great vessels. The parietal peritoneum blends with the anterior layer of the Gerota fascia to form the Toldt line laterally. During surgical approaches to the kidneys, an incision along this line allows the surgeon to expose the peritoneum with the mesocolon through a relatively avascular plane and gives access to the retroperitoneum.

Anatomic Relations
The upper pole of the left kidney lies at the level of the 12th thoracic vertebra, and the lower pole lies at the level of the third lumbar vertebra. The right kidney typically extends from the top of the first lumbar vertebra to the bottom of the third lumbar vertebra. Because of the free mobility of the kidneys, these relationships change with both body position and respiration. The right adrenal gland covers most parts of the anteromedial surface of the right kidney. The anterior relationships of the right kidney include the liver and the hepatic flexure of the colon, which covers the upper and lower pole, respectively. The right renal hilum is overlapped by the second part of the duodenum. Mobilizing the duodenum with the Kocher maneuver is an important step for right renal hilar exposure. The anterior surface of the kidney,
underneath the liver, is the only area covered by peritoneum within the Morrison space. The hepatorenal ligament, an extension of the parietal peritoneum, connects the right renal upper pole to the posterior liver. The anteromedial surface of the left kidney upper pole is also covered by the left adrenal gland. The spleen, tail of the pancreas, stomach, and splenorenal ligament joins the spleen to the left kidney. A disproportionate caudal traction or tension to the kidney can lead to capsular rupture of the spleen. The area of the kidney beneath the small intestine, the spleen, and the stomach is covered by the peritoneum. Both the kidneys share relatively symmetric relations to the posterior abdominal wall. The upper pole of each kidney lies on the diaphragm, behind which is the pleural reflection. The superior border of the left kidney typically corresponds to the 11th rib, whereas the superior aspect of the right kidney, which is lower, is usually at the level of the 11th intercostal space. The lower two-thirds of the posterior surface of both kidneys lies on three muscles: the psoas major, the quadratus lumborum, and the aponeurosis of the transversus abdominis muscles (Figs. 2.65 and 2.66).

**Vascular Supply**

A renal artery and a larger renal vein, arising from the aorta and the IVC, respectively, at the level of the second lumbar vertebra supply each kidney. These vessels enter the renal hilum medially, with the vein anterior to the artery, and both lie anterior to the renal pelvis. Although the right kidney is lower than the left kidney, the right renal artery arises from the aorta at a higher level and takes a longer course than the left renal artery. The right renal artery travels caudally behind the IVC to reach the right kidney, whereas the left renal artery passes slightly upward to reach the left kidney. Multiple variations unilaterally and bilaterally are found in the general population. Lower pole renal arteries that pass anterior to the ureteropelvic junction can be the cause of ureteropelvic junction obstruction. Variations of the renal venous anatomy include left circumaortic, left retroaortic, and double and triple renal veins (see Fig. 2.59). Multiple renal veins are found in up to one-third of individuals. Two small but important branches arise from the main renal artery before its termination in the hilum: the inferior adrenal artery and the artery that supplies the renal pelvis and upper ureter. Ligation of this branch may result in ischemia to the proximal ureter with stricture formation. The main renal artery divides into five segmental arteries at the renal hilum. Each segmental artery is an end artery; consequently, occlusion will produce segmental renal ischemia and infarction.

**Lymphatic Drainage**

Lymphatic vessels within the renal parenchyma consist of cortical and medullary plexuses that follow the renal vessels to the renal sinus and form several large lymphatic trunks. The renal sinus is the site of numerous communications between lymphatic vessels from the perirenal tissues, renal
pelvis, and upper ureter. Initial lymphatic drainage runs to the nodes present at the renal hilum lying close to the renal vein. These nodes form the first station for the lymphatic spread of renal cancer. On the left side, the lymphatic trunks from the renal hilum drain to the paraaortic lymph nodes from the level of the IMA to the diaphragm. Lymphatic vessels from the right kidney drain into the lateral paracaval and interaortocaval nodes.

**Ureters**
The ureter is a muscular tube that follows an S-shaped course in the retroperitoneum. The muscle fibers are arranged in three separate layers: inner and outer longitudinal and middle circular. The length of the ureter in the adult is 28 to 34 cm, varying in relation to the height of the person. The average diameter of the ureter is 10 mm in the abdomen and 5 mm in the pelvis. However, three areas of physiologic narrowing in the ureter should not be considered abnormal unless the proximal ureter is significantly dilated: the ureteropelvic junction, the point where the ureter crosses over the iliac vessels, and the ureterovesical junction. Both ureters have the same posterior relations, lying on the medial aspect of the psoas major muscle and traveling downward adjacent to the transverse processes of the lumbar vertebrae. Just proximal to their midpoints, both ureters cross behind the gonadal vessels. The right ureter passes behind the second part of the duodenum, lateral to the IVC, and is crossed by the right colic and ileocolic vessels. The left ureter passes behind the left colic vessels, descends parallel to the aorta, and passes under the pelvic mesocolon. The upper ureter derives its blood supply from a ureteric branch of the renal artery. During their course in the abdomen, the ureters receive blood from the gonadal vessels, aorta, and retroperitoneal vessels. In the pelvis, they receive additional branches from the internal iliac, middle rectal, uterine, vaginal, and vesical arteries. The abdominal portion of the ureter has a medial vascular supply; the pelvic portion receives its vasculature laterally. This should be taken into consideration during partial mobilization of the ureter to preserve as much blood supply as possible. In case of complete mobilization, the adventitia must be carefully preserved (Fig. 2.67).

**Anatomy of the Upper Abdomen and Midabdomen**

**The Diaphragm**
The diaphragm is a musculofibrous sheet separating the thorax and the abdomen. It takes the shape of an elliptical cylindroid crowned with a dome, resembling two domes at each side of a central platform. The thoracic outlet determines this elliptical shape. The skeletal attachments of the diaphragm to the thoracic outlet originate at the xiphoid process and sternum centrally and, moving laterally, include the ventral ends and costal cartilages of ribs 7 to 12, the transverse processes of the first lumbar vertebra, and the bodies of the first three lumbar vertebrae.

**Diaphragmatic Attachments**
The sternal part is joined to the back of the xiphoid process. The costal part is attached to the internal surfaces of the lower six costal cartilages and their contiguous ribs; the vertical muscular fibers of the diaphragm link with the horizontal fibers from the transversus abdominis muscle. The lumbar part is attached to the aponeurotic medial and lateral arcuate ligaments or lumbocostal arches and to the upper three lumbar vertebrae by the diaphragmatic crura. The sternocostal and lumbar portions are embryologically different and in most cases are separated by a hiatus in the muscular sheet.
This gap lies above the 12th rib so that the upper pole of the kidney is separated from the pleura by lax areolar tissue only. The lateral arcuate ligament is a thickened band in the fascia of the quadratus lumborum, which arches across the muscle and is attached medially to the front of the first transverse process and laterally to the inferior margin of the 12th vertebra near its midpoint. The medial arcuate ligament is a thickened band in the fascia covering the psoas major. Medially, it blends with the lateral tendinous margin of the corresponding crus and is thus attached to the side of the first or second lumbar vertebra. Laterally, it is attached to the front of the first lumbar transverse process at the lateral margin of the psoas. The crura show a tendinous part at their attachments, merging with the anterior longitudinal vertebral ligament. The right crus is broader and longer and arises from the anterolateral aspect of the bodies and discs of the first lumbar vertebrae. The left crus arises from the corresponding parts of the upper two vertebrae. The fibers of the crura ascend and run anteriorly, crossing the aorta in a median arch, where the tendinous margins meet to form the median arcuate ligament. The fibers of the pillars continue anteriorly and cranially while they are divided into medial and lateral bundles. The lateral bundle continues laterally to reach the central tendon. The medial fibers from the right crus ascend to the left of the esophageal opening. The deeper medial right crural fibers cover the right margin of the esophageal opening. The suspensory muscle of the duodenum originates from part of the right crus near the esophageal opening.

Central Tendon of the Diaphragm
All the muscular fibers converge on the central tendon of the diaphragm. The central tendon is a thin, strong aponeurosis of interlaced collagen fibers, with its anterior margin closer to the front of the diaphragm.

Diaphragmatic Apertures
As the diaphragm separates the abdominal and thoracic cavities, there are several structures that will either cross through it or between it and the body wall, including blood vessels, nerves, and the esophagus (Fig. 2.68). There are various openings to allow the passage of these structures, three of which are large and constant. The aortic opening, the most inferior and posterior, lies at the level of the lower border of the 12th thoracic vertebra, to the left of the midline. This is not a true opening; it is actually behind the diaphragm or the median arcuate ligament. Along with the aorta, generally to the right of the midline, runs the thoracic duct, posterolaterally to which are the azygos vein on the right and the hemiazygos vein on the left. Lymphatic trunks also descend through the opening from the lower posterior thoracic wall. The esophageal orifice is oval and lies at the level of the 10th thoracic vertebra, where its long axis lies obliquely, ascending to the left of the midline in the muscular part of the right crus, which has by now crossed over the midline. It conducts the esophagus, the vagus nerves, and the esophageal branches of the left gastric vessels and lymphatic vessels. The muscles of the esophageal wall and the diaphragm remain separate. The opening of the vena cava is the highest of the three and lies approximately at the level of the disc between the eighth and ninth thoracic vertebrae (Fig. 2.69). It is located within the central tendon, at the junction of its right side within the central area. Therefore the opening border is aponeurotic; the vena cava adheres to it as it traverses the opening. The right phrenic nerve crosses the opening. The left phrenic nerve runs off the pericardium to penetrate the muscular part of the diaphragm on the left limb of the central tendon. There are various minor apertures. Two lesser apertures in each crus contain the greater and lesser splanchnic nerves. The ganglionated sympathetic trunks run from the thorax to the abdomen behind the medial end of the
The right hemidiaphragm after a peritoneal stripping is shown. Note the pathway run by the right diaphragmatic vessels.

**Nerve Supply**

The diaphragm takes its nerve supply predominantly from the phrenic nerve (C3–C5). The right phrenic nerve reaches the diaphragm just lateral to the IVC. The left phrenic nerve joins the diaphragm just lateral to the border of the heart, in a more anterior plane than the right phrenic nerve. The nerves divide at the level of the diaphragm, or just above it, into several terminal branches. The phrenic nerve provides the motor supply to the diaphragm. The phrenic nerve also supplies the majority of the phrenic branches of the lower thoracic aorta supply the superior surface. There is also a supply from the lower five intercostal and subcostal arteries. The inferior surface is supplied by the inferior phrenic arteries, which are branches of the abdominal aorta, although sometimes they may be branches of the celiac trunk (Fig. 2.70). The venous drainage mirrors the arterial blood supply. The superior surface drains through the pericardiophrenic, musculophrenic, and superior epigastric veins, which drain into the internal thoracic vein. The inferior surface of the diaphragm drains through the inferior phrenic veins. The right vein drains to the IVC. The left is often double, the anterior branch going to the IVC, and the posterior branch to the left renal or suprarenal vein. The two veins may anastomose with each other.

**Lymphatic Drainage**

The diaphragmatic lymph nodes on the thoracic surface of the diaphragm form three groups. The anterior or pericardiophrenic group is located anterior to the pericardium, posterior to the xiphoid process, just in the cardiophrenic fat. They receive efferents from the anterior part of the diaphragm, the pleura, and the anterosuperior portion of the liver. They drain to the internal mammary nodes alongside the xiphoid. The juxtaphrenic or lateral group receives lymph from the central portion of the diaphragm and from the convex surface of the right hepatic lobe. The retrocrural nodes lie behind the diaphragmatic crura and anterior to the spine, receive lymph from the posterior part of the diaphragm, and communicate with the posterior mediastinal and paraaortic nodes.

**The Stomach**

The stomach is the most dilated part of the digestive tube, having a capacity of 1000 to 1500 mL in the adult. It is situated between the end of the esophagus and the duodenum—the beginning of the small intestine. It lies in the epigastric, umbilical, and left hypochondrial regions of the abdomen and occupies a space limited by the upper abdominal viscera, the anterior abdominal wall, and the diaphragm. It has two openings and two borders, although in reality the external surface is continuous. The relationship of the stomach to the surrounding viscera is altered by the amount of the stomach contents, the stage of the digestive process, the degree of development of the gastric musculature, and the condition of the adjacent intestines. Its borders are defined by the attachments of the greater and lesser omentum, thus dividing the stomach into an anterior and posterior surface.

**Gastroesophageal Junction**

The esophagus connects with the stomach via the cardia, which is situated on the left of the midline at the level of T10. The esophagus, after passing through the diaphragm, curves sharply to the left and becomes continuous with the cardiac orifice of the stomach. The right margin of the esophagus is continuous with the lesser curvature of the stomach; the left margin joins the greater curvature at an acute angle.

**Gastroduodenal Junction**

The pylorus forms the gastric outlet and communicates with the duodenum. It lies to the right of the midline at the level of the upper border of L1 and may be identified on the surface of the stomach by a circular indentation.

**Lesser Curvature**

The lesser curvature extends from the cardiac to the pyloric orifices, thus forming the right or posterior border of the stomach. It is a continuation of the right border of the esophagus and lies in front of the right crus of the diaphragm. It crosses the body of L1 and ends at the pylorus. A well-demarcated notch, the incisura angularis, is located on the lesser curvature of the stomach near the pylorus. Attached to the lesser curvature are the two layers of the lesser omentum or hepatogastric ligament.
Between these two layers are the left gastric artery and the right gastric branch of the hepatic artery (Fig. 2.71).

Greater Curvature
The greater curvature is four times longer than the lesser curvature. It starts from the incisura cardiaica, showing an acute angle termed the cardiac notch, and arches to the left. It then descends downward and forward, with a slight convexity to the left before turning to the right, to end at the pylorus. Directly opposite the incisura angularis of the lesser curvature, there is a dilation of the greater curvature, which defines the left border of the pyloric area. This dilation is limited on the right by a slight groove, the sulcus intermedium, which is about 2.5 cm from the duodenopyloric constriction. The portion between the sulcus intermedium and the duodenopyloric constriction is termed the pyloric antrum. At its commencement the greater curvature is covered by peritoneum continuous with that covering its anterior wall. The left curvature gives attachment to the gastroepiploic ligament and is joined by the two layers of the greater omentum, separated by the right and left gastroepiploic vessels (Fig. 2.72).

Anterosuperior Surface
The anterosuperior surface is covered by peritoneum and lies in contact with the diaphragm, which separates it from the base of the left lung, the pericardium, the seventh to ninth ribs, and the intercostal spaces of the left side. The right half lies in relation to the left and quadrate lobes of the liver, together with the anterior abdominal wall. The transverse colon may lie on the front part of this surface when the stomach is collapsed.

Posteroinferior Surface
The posteroinferior surface is covered by peritoneum, except over a small area close to the cardiac orifice; this area is limited by the lines of attachment of the gastrophrenic ligament and lies in apposition to the diaphragm and frequently with the upper portion of the left suprarenal gland. Other relations are to the upper part of the front of the left kidney, the anterior surface of the pancreas, the left colic flexure, and the upper layer of the transverse mesocolon. The transverse mesocolon separates the stomach from the duodenojejunal flexure and small intestine. Thus the abdominal cavity is divided into supracolic and infracolic compartments. The anterior boundary of the lesser sac, denominated as omental bursa, is formed by this surface. This potential space can be accessed through an opening on the free border of the lesser omentum, which contains the common hepatic artery, the common bile duct, and the portal vein. This gate to the omental bursa is called the foramen of Winslow.

Segments of the Stomach
The stomach is divided into the pyloric part and body by a plane passing through the incisura angularis on the lesser curvature and the left border of the opposing dilation on the greater curvature. The body is further subdivided into the fundus and cardia by a plane passing horizontally through the cardiac orifice. Distally, a plane passing from the sulcus intermedium at a right angle to the long axis of this portion further subdivides the pyloric portion. To the right of this plane lies the pyloric antrum.

Lesser Omentum
The lesser omentum, also called the small omentum or gastrohepatic omentum, is the double layer of peritoneum that extends from the liver to the lesser curvature of the stomach (hepatogastric ligament) and the first part of the duodenum (hepatoduodenal ligament).

The lesser omentum extends from the inferior and posterior surfaces of the liver to the stomach and proximal 3 cm of the duodenum. The free border of the lesser omentum between the porta hepatitis and the duodenum contains the hepatic artery, the portal vein, the common bile duct, lymph glands, lymph vessels, and nerves, forming the hepatic hilum. Behind this free edge is the opening into the lesser sac or foramen of Winslow. The remainder of the lesser omentum, extending from the left end of the porta hepatitis to the lesser curvature, includes the right and left gastric arteries and the associated veins, as well as lymph glands, lymph vessels, and branches of the anterior and posterior vagus nerves.

Greater Omentum
The greater omentum is formed along the greater curvature of the stomach by the union of the peritoneal layers of the anterior and posterior gastric surfaces. On its left it condenses into the...
gastroplenic omentum, containing the short gastric branches of the splenic artery between its two layers (Fig. 2.73). On the right it continues for 3 cm along the lower border of the first part of the duodenum.

From its origin the greater omentum is suspended in front of the intestines as a lax apron, extending as far as the transverse colon (Fig. 2.74), where its two layers separate to enclose that part of the colon. The upper part of the greater omentum contains the greater part of the right and left gastroepiploic arteries and their additional veins, lymph vessels, lymph glands, and nerves.

**Blood Supply of the Stomach**

**Arterial Supply**
- The celiac artery supplies the stomach by its three branches. It arises from the ventral part of the aorta below the crura of the diaphragm and is a short and wide trunk, bordered by the celiac lymph nodes and flanked by the celiac ganglia of the sympathetic system. The main branches are the left gastric artery, the hepatic artery, and the splenic artery.

![FIG. 2.73](image1) The anatomic relations of the left portion of the greater omentum, the pancreatic tail, and the splenic hilum.

![FIG. 2.74](image2) The transverse colon has been exteriorized, showing the insertion of the greater omentum over the antimesenteric border of the bowel.

- The left gastric artery runs to the left, gives off an ascending esophageal branch, and supplies the upper part of the stomach. However, it may arise directly from the aorta and may provide one or both of the inferior phrenic arteries or a common trunk for the two. The left gastric artery turns downward between the layers of the lesser omentum and runs to the right along the lesser curvature. Then it divides, supplying the anterior and posterior gastric walls. These vessels anastomose freely with arteries from the greater curvature. Around the incisura angularis, the two main branches anastomose with the two branches of the right gastric artery. The hepatic artery may arise directly from the left gastric artery.
- The hepatic artery is the second branch of the celiac trunk and reaches the first part of the duodenum. At the opening of the lesser sac it curves upward between the two layers of the lesser omentum toward the porta hepatis, to supply the liver. The gastroduodenal and right gastric branches are given off as it turns into the lesser omentum. The right gastric artery is found between the two layers of the lesser omentum and runs along the lesser curvature of the stomach before dividing into two branches that anastomose with the branches of the left gastric artery. It also gives off branches to the anterior and posterior gastric walls, anastomosing with branches from the right gastroepiploic artery. The gastroduodenal artery descends behind the first part of the duodenum, providing its blood supply by multiple small branches. The terminal divisions are the superior pancreaticoduodenal artery, supplying the second part of the duodenum and head of the pancreas, and the right gastroepiploic artery. The right gastroepiploic artery passes along the greater curvature of the stomach between the layers of the greater omentum and gives off branches to the anterior and posterior gastric walls before anastomosing with the left gastroepiploic artery.
- The splenic artery follows a tortuous course to the left along the upper border of the pancreas, behind the peritoneum and the stomach, and ends in the spleen. It provides blood supply to the pancreas. Just before entering the splenic hilum it gives off the short gastric arteries, supplying the gastric fornix, and the left gastroepiploic artery. The latter passes downward along the greater curvature of the stomach, between the two layers of the greater omentum, to anastomose with the right gastroepiploic artery at the midportion of the greater curvature. The left gastroepiploic artery gives off branches to the anterior and posterior gastric walls, which anastomose with branches of the gastric arteries along the lesser curvature. These arterial arcades ramify through the submucosa, forming a rich arterial network from which branches arise to supply the mucous membrane. Therefore the mucosa is not supplied by end arteries, with the possible exception of the mucosa along the lesser curvature, which appears to receive its arterial supply directly from branches of the right and left gastric arteries. Multiple variations of the splenic artery are reported.

**Venous Drainage**

The gastric veins are similar in position to the arteries along the lesser and greater curvatures. These veins drain either directly or indirectly into the portal system.
- The left gastric vein runs to the left along the lesser curvature, receiving the esophageal veins below the esophageal hiatus in the diaphragm. It usually drains directly into the portal vein at the superior border of the pancreas.
• The right gastric vein runs along the lesser curvature to the right toward the pylorus. Posterior to the first part of the duodenum, it joins the portal vein. It also receives the prepyloric vein, which receives the veins from the first 2 cm of the duodenum.

• The left gastroepiploic vein passes to the left along the greater curvature and, with the short gastric veins, drains into the splenic vein or its tributaries. The splenic vein is joined by tributaries from the pancreas as well as the inferior mesenteric vein; these ultimately form the portal vein with the superior mesenteric vein.

• The right gastroepiploic vein runs toward the right to the head of the pancreas. Usually it joins the superior mesenteric vein and thus drains into the portal vein.

Lymphatic Drainage

The lymphatic drainage of the stomach can be divided into four areas:

• Area 1 comprises the upper two-thirds of the lesser curvature and a large part of the body of the stomach. These drain into the left gastric nodes lying along the left gastric artery. These nodes are joined by lymphatics coming down from the lower part of the esophagus and continue to the celiac nodes.

• Area 2 drains the distal part of the lesser curvature to the suprapyloric nodes along the right gastric artery. Efferent channels from the suprapyloric nodes drain to the hepatic and ultimately to the celiac and aortic nodes.

• Area 3 includes the pyloric part as well as the right half of the greater curvature. The lymphatics from these areas drain into the right gastroepiploic nodes in the gastrocolic ligament, lying along the right gastroepiploic vessels, and into the pyloric nodes on the anterior surface of the head of the pancreas. The direction of lymph flow is toward the pylorus, head of the pancreas, and second part of the duodenum. The efferent lymphatics pass along the gastroduodenal artery to the hepatic nodes along the hepatic artery, and to the celiac nodes.

• Area 4 comprises the left half of the greater curvature and the gastric fundus. The lymphatic vessels in this area connect to the left gastroepiploic nodes, lying along the left gastroepiploic artery. These drain to the pancreatosplenic nodes along the splenic artery, before terminating in the celiac nodes.

Nerves of the Stomach

The autonomic nervous system consists of two components: cholinergic (mostly parasympathetic) and adrenergic (mostly sympathetic) nerves. However, a third component of the autonomic system, the peptidergic system, has been recognized within the gastrointestinal tract.

Parasympathetic Nerve Supply

The anterior and posterior vagal trunks and their branches form the parasympathetic nerve supply to the stomach. Afferent fibers are also present in the vagus nerves.

Anterior Vagus. The anterior vagus is derived mainly from the left vagus nerve but also includes fibers from the right vagus and also some sympathetic fibers from the splanchnic nerves. It enters the abdominal cavity through the esophageal hiatus in the diaphragm. It is usually single but may be divided into multiple trunks. Having given off several fine branches to the lower end of the esophagus and cardiac part of the stomach, the anterior trunk breaks up into its main branches.

There are three main sets of branches:

• Bundle 1 consists of four or five direct branches to supply the upper part of the lesser curvature. A few filaments from the sympathetic supply join these direct branches via the celiac plexus.

• Bundle 2 is formed by branches from the vagal supply to the liver. There are usually three to five nerves, and they descend in the lesser omentum and continue to the superior margin of the pylorus and first part of the duodenum.

• Bundle 3 consists of vagal filaments from the hepatic branches. These accompany the sympathetic nerves along the right gastroepiploic artery and provide vagal innervation to the inferior margin of the pylorus.

Posterior Vagus. The posterior vagus is mainly formed by fibers from the right vagus nerve and enters the abdomen posterior to the esophagus. After entering the abdomen, it divides into two main branches: the celiac and the posterior gastric. It then continues along the lesser curvature, innervating the posterior gastric wall, although extending only to the incisura angularis.

Sympathetic Nerve Supply

The sympathetic nerve supply is derived almost entirely from the celiac plexus. The gastric branches of the celiac plexus accompany the vessels supplying the stomach—left gastric, hepatic, and phrenic arteries. Others accompany the splenic, right gastric, and gastroepiploic vessels. Fibers from the celiac plexus accompany the left inferior phrenic artery, pass anterior to the lower esophagus, and communicate with the anterior vagus before being distributed to the cardia and fundus. Other fibers travel with the left gastric artery and divide into three groups:

• Those passing with the esophageal and superior branches of the left gastric artery to the cardia and proximal part of the body of the stomach. These communicate with branches of the anterior and posterior vagal trunks.

• Those passing with the main branch of the left gastric artery along the lesser curvature to supply the anterior and posterior surfaces of the body of the stomach and antrum.

• Those passing through the lesser omentum toward the porta hepatis. These communicate with hepatic branches of the anterior vagal trunk.

Duodenum and Pancreas

The duodenum is the first section of the small intestine connecting the stomach to the jejunum. It is 25 to 35 cm in length. It begins with the duodenal bulb and ends at the suspensory muscle of the duodenum. It can be divided into four parts (Figs. 2.75 and 2.76):

• The first portion of the duodenum is approximately 5 cm long and passes upward from the pylorus to the neck of the gallbladder. It is related posteriorly to the common bile duct, portal vein, IVC, and gastroduodenal artery; anteriorly to the quadrate lobe of the liver; superiorly to the epiploic foramen; and inferiorly to the head of the pancreas. The first 2.5-cm portion is intraperitoneal and covered by the same two layers of peritoneum that overlie the stomach. The hepatoduodenal portion of the lesser omentum attaches to the superior border of the duodenum; the greater omentum attaches to its
The third horizontal portion of the duodenum is approximately 10 cm long and extends from the right side of L3 or L4 to the left side of the aorta. It begins about 5 cm from the midline, to the right of the lower end of L3 at the level of the subcostal plane. It passes in a transverse direction to the left, anterior to the ureter, right gonadal vessels, psoas muscle, IVC, lumbar vertebral column, and aorta, and ends to the left of L3. The inframesocolic portion of the duodenum is covered anteriorly by the peritoneum. The superior mesenteric vessels cross it anteriorly. Near its termination, the root of the mesentery of the small intestine crosses it. This third portion is related superiorly to the head and uncinate process of the pancreas. The inferior pancreaticoduodenal artery lies in a groove at the interface of the pancreas and the duodenum. Anteriorly and inferiorly, this part of the duodenum is related to the small bowel, primarily to the jejunum.

The head of the pancreas is attached to the second and third portions, and there is a pancreatic bare area of the duodenum not covered by peritoneum. A second bare area exists on the anterior surface of the second segment, where the transverse colon is attached.

The fourth ascending portion of the duodenum is approximately 2.5 cm long and extends from the left side of the aorta to the left upper border of L2 and is directly oblique upward and slightly to the left. It ends at the duodenojejunal junction, flexure at the level of L2, at the root of the transverse mesocolon. The fourth portion is related posteriorly to the left sympathetic trunk, the psoas muscle, the left renal and gonadal vessels, the inferior mesenteric vein, the left ureter, and the left kidney. The upper end of the root of the mesentery also attaches here. The duodenojejunal junction is suspended by the ligament of Treitz, a remnant of the dorsal mesentery, which extends from the duodenojejunal flexure to the right crus of the diaphragm.

The Pancreas

The pancreas is an elongated organ with a lobular surface extending from the duodenum to the hilum of the spleen. The gland is retroperitoneal and divided anatomically into the uncinate process, head, neck, body, and tail. The head lies to the right of the second lumbar vertebra in apposition to the duodenum. The uncinate process lies posterior to the head, extends medially to lie beneath the superior mesenteric vessels, and contacts the vena cava posteriorly. The neck is a narrowed 2.0- to 2.5-cm portion of the gland that lies directly over the superior mesenteric vein and beneath the first portion of the duodenum. There are some vascular attachments between the neck and the superior mesenteric vein. Development of the plane between these structures is a critical step in performing pancreatic resection. The body extends across the second lumbar vertebral body, anterior to the left kidney, and tapers slightly caudally into the tail, terminating in or near the splenic hilum. The anterior surface of the pancreas is covered by the parietal peritoneum, which separates the gland from the stomach. The inferior surface adjoins the transverse mesocolon and is closely associated with the duodenojejunal junction. The splenic vein is imbedded by varying degrees in the posterior surface of the pancreas and is occasionally completely encased by pancreatic tissue. The splenic artery runs a tortuous course along the superior edge of the gland toward the spleen (Figs. 2.77 and 2.78). The main pancreatic duct originates in the tail and travels longitudinally through the
Chapter 2 Abdominal and Pelvic Anatomy

Abdominal and Pelvic Anatomy

39

gland to the head, where in most cases it turns slightly caudally and posteriorly to its termination in the duodenal papilla within the second segment of this organ. The pancreatic duct and the bile duct terminate in the duodenum at the ampulla of Vater. The major papilla is an elevation of the duodenal mucosa at the point where the common bile duct and the pancreatic duct enter the duodenum. It is usually 7 to 10 cm from the pylorus but may be as close as 1.5 cm or as distant as 12 cm. The bile duct and the pancreatic duct typically join to form a common channel of varying length within the papilla. In a minority of cases, the two ducts enter the duodenum separately through the papilla, in which case the ampulla is absent. In rare instances the ducts may enter the duodenum via separate papillae. Like the papilla of Vater, the sphincter of Oddi consists of annular fibers around the entire intramural portion of the bile duct that prevent the reflux of duodenal contents.

Blood Supply of the Pancreas and Duodenum

Arterial Supply

The pancreas has an extremely rich blood supply from varied sources, the most major of which is the branches of the gastroduodenal, superior mesenteric, and splenic or celiac arteries. Numerous smaller tributaries arise from the splenic, hepatic, and gastroduodenal arteries. The blood supply of the pancreas and the duodenum is complex owing to the diverse distribution and individual variations.

• The supraduodenal artery and the posterosuperior pancreaticoduodenal branches of the hepatic artery supply the very first portion of the duodenum. In many patients this portion is also supplied by branches of the right gastric artery.

• After giving off the supraduodenal, retroduodenal, and posterosuperior pancreaticoduodenal branches, the gastroduodenal artery descends between the first part of the duodenum and the head of the pancreas. It terminates by dividing into the right gastroepiploic and anterosuperior pancreaticoduodenal arteries, both supplying the first part of the duodenum.

• An anterior and a posterior arcade originating from the gastroduodenal and pancreaticoduodenal arteries supply the remaining three parts of the duodenum. Pancreatic and duodenal branches emanate from these arcades.

• The gastroduodenal artery is crucial in the pancreatic arterial anatomy. It arises from the hepatic artery approximately 2 cm from its origin and passes medially and inferiorly to the common bile duct.

• The anterosuperior pancreaticoduodenal artery is a continuation of the gastroduodenal artery and passes downward and through the sulcus between the duodenum and the pancreas. It continues and anastomoses with the inferior pancreaticoduodenal artery along the medial surface of the duodenum. The posterosuperior pancreaticoduodenal artery branches from the gastroduodenal artery at the superior border of the pancreas and traverses posteriorly behind the pancreas, crossing medially to anastomose with the posterosuperior pancreaticoduodenal artery.

• Two other major arterial branches supplying the body and the tail of the pancreas are the inferoanterior and the inferoposterior pancreaticoduodenal arteries. These two arteries arise from the SMA, or one of its primary branches, and form an arcade that supplies the duodenojejunal junction and portions of the pancreatic neck.

• The superior dorsal pancreatic artery is somewhat inconsistent but, when present, arises from either the celiac or the splenic artery and courses along the superior border of the body and the tail of the pancreas.

• The inferior transverse pancreatic artery is fairly constant and arises from the SMA, the superoanterior pancreaticoduodenal artery, or the superior dorsal pancreatic artery, and passes through the body of the pancreas along the inferior margin of the gland. The body and the tail of the gland receive numerous branches from the splenic artery as it courses along the superior border of the gland.

Venous Drainage

The subpyloric veins, which drain the lower first part of the duodenum and the pylorus, usually drain into the right gastroepiploic veins. The upper first part of the duodenum is drained by suprayloric veins, which drain into the portal vein or the posterosuperior pancreaticoduodenal vein. Anastomoses between subpyloric and suprapyloric veins pass around the duodenum. The venous arcades draining the duodenum follow the arterial arcades. The anterosuperior vein drains into the right gastroepiploic vein. The posterosuperior vein passes.

FIG. 2.77 Spleen has been mobilized, and the forcep demonstrates the tail of the pancreas and the splenic vein.

FIG. 2.78 The splenic hilum is grasped with the hand on the external edge of the tail of the pancreas.
behind the common bile duct to enter the portal vein. The inferior veins can enter the superior or the inferior mesenteric veins, the splenic vein, or the first jejunal branch of the superior mesenteric vein. The veins may terminate separately or by a common stem. The superior mesenteric, splenic, and portal vein are intimately associated with the pancreas. The anterior surface of the superior mesenteric vein passes directly beneath the neck of the gland and rarely receives tributaries. The splenic vein receives numerous branches from the body and the tail of the pancreas along its course to its junction with the superior mesenteric vein, beneath the neck of the gland. The inferior mesenteric vein is constant in its course but variable in its drainage into either the splenic vein or the superior mesenteric vein. The left gastric vein is constant in its course along the lesser curve of the stomach but terminates at the splenoportal junction or along the portal vein at some distance from the splenoportal junction. This trunk is ligated for exposure of the anterior surface of the pancreas. The head of the gland is drained via an arcade of venous structures forming the anterosuperior pancreaticoduodenal vein and the anteroinferior pancreaticoduodenal veins. The former receives numerous duodenal tributaries and passes upward and medially from the duodenojejunal junction to enter the gastrocolic trunk. The latter passes medially through the substance of the pancreas, joining a jejunal tributary of the superior mesenteric vein. Two significant veins, the posterosuperior and posteroinferior pancreaticoduodenal veins, drain the posterior aspect of the head. The superior vein courses behind the bile duct and wraps medially to drain directly into the portal vein, and the inferior vein passes around the superior mesenteric vein and drains into its first duodenojejunal tributary.

The right gastroepiploic vein courses along the greater curvature of the stomach between the two leaves of the gastroduodenal ligament and curves downward where it joins the superior mesenteric vein, just below the neck of the pancreas. The right gastroepiploic vein is significant because it is joined, near its insertion into the superior mesenteric vein, by the inferosuperior duodenal vein and one or more colic veins. This short but relatively broad attachment is called the gastroduodenal trunk. The superior portion of the neck and body of the pancreas is drained through multiple short tributaries into the splenic vein. The inferior portions are drained by a relatively constant inferior pancreatic vein, which courses along the inferior border of the body of the gland, and commonly empty into either side of the superior mesenteric vein.

**Lymphatic Drainage**

The duodenum is richly supplied with lymphatic vessels. Collecting trunks pass over the anterior and the posterior duodenal wall toward the lesser curvature to enter the anterior and posterior pancreaticoduodenal lymph nodes. The anterior extramural collecting ducts drain into the nodes anterior to the pancreas. The posterior ducts drain to the nodes posterior to the head of the pancreas. The lymphatic ducts follow the veins and the arteries to connect with the nodes adjacent to the SMA.

**Nerves of the Duodenum and Pancreas**

Within the duodenal wall are the two well-known neural plexuses of the gastrointestinal tract, each of which is composed of groups of neurons interconnected by networks of fibers. The plexus of Meissner is in the submucosa, and the plexus of Auerbach is in the connective tissue between the circular and longitudinal layers of the muscularis externa. Some of the neuronal cell bodies and processes in the plexuses are assumed to be preganglionic parasympathetic fibers. The preganglionic parasympathetic fibers in the plexuses are carried initially by the vagus nerves. The preganglionic sympathetic fibers arise from cell bodies located in the celiac and superior mesenteric plexuses and also, perhaps, in the upper thoracic sympathetic chain ganglia. The extrinsic nerve supply to the duodenum probably includes contributions that leave the anterior hepatic plexus close to the origin of the right gastric artery. In most specimens, some branches can be traced upward to the gastric incisura.

Pancreatic nerves follow the blood supply. Sympathetic fibers travel via the celiac ganglion, where preganglionic efferent fibers pass before reaching the pancreas. The sympathetic efferent fibers are located in the dorsal root ganglia T10 through T12, which are important for operations to relieve pain from chronic pancreatitis or pancreas exocrine cancer. The parasympathetic fibers invade the pancreas via the vagus nerve, having their cell bodies in the brain.

**The Liver**

The liver is the largest organ of the body, accounting for approximately 2% to 4% of body weight. The liver has two lobes that have been described in two ways: by morphologic and functional anatomy. It is found within the right upper quadrant of the abdominal cavity under the right hemidiaphragm; it is protected by the ribs and maintains its position by virtue of the peritoneal reflections or ligamentous attachments. Although they are not true ligaments, these attachments are avascular and are in continuity with the Glisson capsule, the equivalent of the visceral peritoneum of the liver.

**Ligamentous Attachments**

The falciform ligament arises at the umbilicus and continues toward the anterior aspect of the liver in continuity with the umbilical fissure (Fig. 2.79). The falciform ligament courses cranially along the anterior surface of the liver, merging with the Glisson capsule and coursing upward to become the anterior portion of the left and right coronary ligaments. The hepatic veins drain into the IVC at the base of the falciform
ligament. Within the lower border of the falciform ligament is the ligamentum teres or round ligament of the liver, a vestige of the obliterated umbilical vein or ductus venous that runs from the umbilicus into the umbilical fissure, where it is in continuity with the ligamentum venosum as it joins the left branch of the portal vein. The ligamentum venosum lies within a fissure on the inferior surface of the liver between the caudate lobe posteriorly and the left lobe anteriorly. During fetal development, the ductus venosus is responsible for carrying most of the blood flow from the umbilical vein directly into the IVC, transporting oxygenated blood from the placenta to the fetus. After birth, the umbilical vein closes as the physiologic neonatal circulation begins. In the presence of portal hypertension, the umbilical vein may reopen to allow a collateral circulation through the abdominal wall. The coronary ligaments continue in both sides of the falciform ligament as a lateral continuation in form of reflections of the peritoneum of the diaphragm. These areas converge to the left and right of the liver to form the left and right triangular ligaments, respectively. The right coronary and triangular ligaments course posterior and caudally toward the right kidney, attaching the liver to the retroperitoneum. All attachments serve to hold the liver on the right upper quadrant of the abdomen. The mobilization of the liver requires division of these avascular attachments. The liver has close associations with many structures and organs. The IVC maintains an intimate relationship to the caudate lobe and right hepatic lobe by IVC ligaments. These ligaments are bridges of membranous tissue that are extensions of the Glisson capsule from the caudate and right hepatic lobe. In some cases these ligaments may contain hepatic parenchyma, including the portal triads and hepatocytes.

**Perihepatic Organs**

The stomach is related to the left hepatic lobe through the gastrohepatic ligament. Important neural and vascular structures run within the gastrohepatic ligament, including the hepatic division of the vagus nerve and, when present, an aberrant left hepatic artery when it courses from its left gastric artery origin. The ascending colon connects to the transverse colon in the hepatic flexure, in direct contact with the right hepatic lobe. In addition, the duodenum and portal structures are linked with the liver through the hepatoduodenal ligament and porta hepatis. Anatomic understanding of the portal anatomy is essential at the time of any hepatic resection and associated vascular and biliary reconstructions. Within the porta hepatis lies the common bile duct, hepatic artery, and portal vein, which course in a lateral, medial, and posterior configuration, respectively (Fig. 2.80). The foramen of Winslow or epiploic foramen has important relevance to the porta hepatis during surgery in this region. The foramen of Winslow, originally described by Dr. Jacob Winslow in 1732, is a communication or connection between the abdominal cavity and the lesser sac. During hepatic resection, complete control of the hepatic vascular inflow may be accomplished by the Pringle maneuver. This maneuver implicates temporary closure of the hepatic artery and portal vein inflow and may be done by placement of a vascular clamp on the porta hepatis or more gently by the use of a band passed through the foramen of Winslow encircling the porta hepatis. The gallbladder resides in the gallbladder fossa at the posterior interface of segments IV and V. It establishes continuity with the common bile duct via the cystic duct. In addition, the cystic artery most commonly arises as a branch off the right hepatic artery. An understanding of portal vasculature and biliary anatomy is crucial, given its wide anatomic variability, to avoid inadvertent injury during any hepatic, pancreatic, biliary, or bowel surgery. In addition, the right adrenal gland lies within the retroperitoneum under the right hepatic lobe. The right adrenal vein drains directly into the IVC (Fig. 2.81); hence, care should be taken during hepatic mobilization to avoid avulsion of the vein or inadvertent dissection into the adrenal gland, which can result in significant hemorrhage.

**Hepatic Segmentation**

The anatomy of the liver can be described using two different aspects: morphologic anatomy and functional anatomy. The traditional morphologic anatomy is based on the external

![FIG. 2.80 Left, Finger passing through the Winslow foramen containing the hepatic hilum. Right, After a thorough dissection, the component of the hepatic hilum can be identified.](image-url)
appearance of the liver and does not show the internal features of vessels and biliary ducts branching, which are of obvious importance in hepatic surgery. The French surgeon and anatomist Claude Couinaud was the first to divide the liver into eight functionally independent segments, allowing resection of single segments without damaging other segments.

**Couinaud Classification**
The Couinaud classification of liver anatomy divides the liver into eight functionally independent segments. Each segment has its own vascular inflow, outflow, and biliary drainage. In the center of each segment is a branch of the portal vein, hepatic artery, and bile duct. In the periphery of each segment, there is vascular outflow through the hepatic veins. The right hepatic vein divides the right lobe into anterior and posterior segments. The middle hepatic vein divides the liver into right and left lobes (or right and left hemilivers). This plane runs from the IVC to the gallbladder fossa. There are eight liver segments. Segment IV is sometimes divided into segments IVa and IVb, according to 4a (superior) and 4b (inferior).

The numbering of the segments is in a clockwise manner. Segment I (the caudate lobe) is located posteriorly. It is not visible on a frontal view. The falciform ligament divides the left lobe into a medial portion (segment IV) and a lateral portion (segments II and III). The portal vein divides the liver into upper and lower segments. The left and right portal veins branch superiorly and inferiorly to project into the center of each segment. On a normal frontal view, the segments VI and VII are not visible because they are located more posteriorly. The right border of the liver is formed by segments V and VIII. Although segment IV is part of the left hemiliver, it is situated more to the right. Couinaud divided the liver into functional left and right livers by a main portal incisura containing the middle hepatic vein. This is known as the Cantlie line. The Cantlie line runs from the middle of the gallbladder fossa anteriorly to the IVC posteriorly (Fig. 2.82).

**Hepatic Vasculature**
The liver is a very vascular organ and at rest receives up to one-fourth of the total cardiac output, more than any other organ. Its dual blood supply is uniquely divided between the hepatic artery, which contributes 25% to 30% of the blood supply, and the portal vein, which is responsible for the remaining 70% to 75%. The arterial and portal blood ultimately mixes within the hepatic sinusoids before draining into the systemic circulation via the hepatic venous system.

**Arterial Vasculature**
Although the arterial vasculature of the liver is variable, the most common configuration is the common hepatic artery originating from the celiac axis along with the left gastric and splenic arteries. The common hepatic artery proceeds laterally...
and branches into the proper hepatic artery and the gastroduodenal artery. The gastroduodenal artery proceeds caudally to supply the pylorus and proximal duodenum and has several indirect branches to the pancreas. The proper hepatic artery courses within the medial aspect of the hepatoduodenal ligament and porta hepatis toward the liver to divide into left and right hepatic arteries to feed the respective hepatic lobes. In addition, the right gastric artery has a variable origin arising from the hepatic artery as it courses laterally. The cystic artery to the gallbladder commonly arises from the right hepatic artery. The most common modifications include aberrant hepatic arteries in which the dominant hepatic arteries do not arise from the proper hepatic artery but rather from an alternate origin. An aberrant left hepatic artery typically arises from the left gastric artery and courses through the lesser omentum to supply the left side of the liver and is seen in approximately 15% of patients. Despite its alternate origin, the aberrant left hepatic artery still enters the liver through the base of the umbilical fissure in a medial orientation, similar to that of a native left hepatic artery. An aberrant right hepatic artery, seen in approximately 20% of patients, most commonly arises from the SMA. Unlike its left hepatic artery counterpart, the aberrant right hepatic artery often courses posterolaterally in the hepatoduodenal ligament to enter the right side of the liver.

**Venous Vasculature**

The portal vein provides the main volume of the nutritive blood supply to the liver. The portal vein forms from the confluence of the superior mesenteric vein and splenic vein behind the neck of the pancreas. Additional venous branches that drain into the portal vein include the left gastric vein or coronary, cystic vein, and tributaries of the right gastric and pancreaticoduodenal veins. The portal vein has no valves and contains a low-pressure system. The left gastric vein becomes a major portosystemic shunt in the face of portal hypertension and creates gastroesophageal varicosities. The main portal vein courses cranially toward the liver as the most inferior structure in the hepatoduodenal ligament and divides into the left and right portal veins near the hepatic hilus plate. A small branch to the right side of the caudate is typically encountered just before or after the main portal vein branching. The left portal vein has two portions: an initial transverse portion and then an umbilical portion as it approaches the umbilical fissure. The left portal vein tends to have a longer extrahepatic course. The transverse portion of the left portal vein approaches the umbilical fissure and takes an abrupt turn toward it to form the umbilical portion as it enters the liver. Within the liver, the umbilical portion of the left portal vein commonly first gives off a branch to segment II before then dividing into branches to segment III and to segment IVa and IVb. The right portal vein often emerges closer to or within the hepatic parenchyma of the right side of the liver itself. It quickly divides into anterior and posterior branches to segments V and VIII and segments VI and VII, respectively. The venous drainage of the liver is through the intrahepatic veins, which ultimately merge into three hepatic veins that drain into the IVC superiorly. The left and middle hepatic veins may drain directly into the IVC but more commonly form a short common trunk before draining into the IVC. The right hepatic vein is typically larger, with a short extrahepatic course, and drains directly into the IVC. Additional drainage occurs directly into the IVC via short retrohepatic veins and, sporadically, an inferior right accessory hepatic vein. Hepatic veins within the parenchyma lack the fibrous venous tissue that the portal venous system has; they are not surrounded by the fibrous tissue encasing the Glisson capsule. This feature can be seen by ultrasound and allows differentiation of both venous systems because the Glisson capsule is surrounding the portal veins, whereas the hepatic veins lack this. The IVC maintains an important and intimate association with the liver as it courses in a craniocaudal direction to the right of the aorta. As the IVC travels cranially, it courses posterior to the duodenum, pancreas, porta hepatis, caudate lobe, and posterior surface of the liver as it approaches the bare area where it receives the hepatic venous outflow from the hepatic veins. Multiple small retrohepatic veins enter the IVC along its course, mostly from the right hepatic lobe. Hence, in mobilizing the liver or during major hepatic resections, it is imperative to maintain mindfulness of the IVC and its vascular tributaries at all times.

**Lymphatic Drainage**

The liver possesses superficial and deep lymphatic networks. The deep network is responsible for greater lymphatic drainage toward lateral phrenic nodes via the hepatic veins and toward the hilum through portal vein branches. The superficial network is located within the Glisson capsule. The anterior surface drains to the phrenic lymph nodes via the bare area of the liver to join the mediastinal and internal mammary lymphatic systems. The posterior surface network drains to hilar lymph nodes, including the cystic duct, common bile duct, hepatic artery, and peripancreatic, pericardial, and celiac lymph nodes. The lymphatic drainage patterns have surgical implications during lymphadenectomy for cancer of the gallbladder, liver, and pancreas.

**Innervation**

The innervation of the liver is complex and not well understood. However, like the remainder of the body, the liver does have parasympathetic and sympathetic neural innervation. Nerve fibers are derived from the celiac plexus, lower thoracic ganglia, right phrenic nerve, and vagus nerves. The vagus nerves divide into an anterior (left) and posterior (right) branch as they course from the thorax into the abdomen. The anterior vagus divides into a cephalic and a hepatic division, of which the latter courses through the lesser omentum.
(gastrohepatic ligament) to innervate the liver and is responsible for the parasympathetic innervation. Sympathetic innervation arises predominantly from the celiac plexus as well as the thoracic splanchnic nerves.

**Intrahepatic Biliary Tree**

The intrahepatic biliary tree is composed of multiple ducts that transport the bile from the liver to the duodenum and typically follow the portal venous system. The right hepatic duct forms from an anterior regional duct from segments V and VIII and a posterior regional duct from segments VI and VII. The right duct typically has a short extrahepatic course with some branching variability. Surgeons should be careful of this variable anatomy when operating at the hilum of the liver. The left hepatic duct drains the left side of the liver and has a course that parallels the left portal vein. The left and right hepatic ducts join near the hilum to form the common hepatic duct. As the common hepatic duct courses caudally, it is joined by the cystic duct to form the common bile duct. The common bile duct proceeds within the lateral aspect of the hepatoduodenal ligament toward the head of the pancreas to drain into the duodenum through the ampulla of Vater. Biliary drainage of the caudate lobe is variable, with drainage observed through the left and right hepatic ducts.

**Extrahepatic Biliary Tract**

The right and left hepatic ducts join after emerging from the liver to form the common hepatic duct. The confluence lies 0.25 to 2.5 cm from the liver surface. The left duct is longer (1.5 cm, average) than the right duct (1 cm, average). In some cases, intrahepatic junction of the hepatic ducts is the result of liver enlargement, and retraction of the liver is indispensable to expose the junction. Measurements of the common hepatic duct are highly variable. In most persons, the duct is 1.5 to 3.5 cm in length.

**Cystic Duct**

The cystic duct is about 3 mm in diameter and about 2 to 4 cm long. If surgeons are unaware of a short duct, they may accidentally enter the common bile duct. When misjudging the length, they may leave too long a stump, predisposing to the cystic duct remnant syndrome. Very rarely, the cystic duct is absent, and the gallbladder opens directly into the common bile duct. In such a case, the common bile duct might be mistaken for the cystic duct.

**Gallbladder**

The gallbladder is located on the visceral surface of the liver in a shallow fossa at the plane dividing the right lobe from the medial segment of the left lobe, the Cantlie line. The gallbladder is separated from the liver by the connective tissue of the Glisson capsule and covered with peritoneum. The body of the gallbladder is in contact with the first and second portions of the duodenum. The body is also related to the transverse colon. The infundibulum is the angulated posterior portion of the body between the neck and the point of entrance to the cystic artery. When this portion is dilated, with eccentric bulging of its medial aspect, it is called a Hartmann pouch. When this pouch achieves considerable size, the cystic duct arises from its upper left aspect rather than from what appears to be the apex of the gallbladder. The pouch may be associated with chronic or acute inflammation because of lithiasis, and often a stone is impacted in the infundibulum. The neck of the gallbladder is S shaped and lies in the free border of the hepatoduodenal ligament. The mucosa covering the neck is a spiral crest said to be a spiral valve, but it is not to be confused with the spiral valve of the cystic duct or the valve of Heister.

**Common Bile Duct**

The length of the common bile duct begins at the union of the cystic and common hepatic ducts and ends at the papilla of Vater in the second part of the duodenum. It varies from 5 to 16 cm depending on the actual position of the ductal union. The duct can be divided into four portions: supraduodenal, retroduodenal, pancreatic, and intramural. The supraduodenal portion lies between the layers of the hepatoduodenal ligament in front of the epiploic foramen of Winslow, to the right or left of the hepatic artery, and anterior to the portal vein. The retroduodenal portion is between the superior margin of the first portion of the duodenum and the superior margin of the head of the pancreas. The gastroduodenal artery lies to the left. The posterior superior pancreaticoduodenal artery lies anterior to the common bile duct. The middle colic artery lies anterior to the duct and other arteries. The common bile duct may be partially covered by a tongue of pancreas or completely within the pancreatic substance. Even when it is completely covered, the channel occupied by the duct may be palpated by passing the fingers of the left hand behind the second part of the duodenum after mobilization with the Kocher maneuver. The normal outside diameter of the first three portions of the common bile duct is variable but less than 8 mm. The intramural portion of the common bile duct passes obliquely through the duodenal wall together with the main pancreatic duct. Within the wall, the length averages 15 mm. As it enters the wall, the common duct decreases in diameter. The two ducts usually lie side by side with a common adventitia for several millimeters.

**Hepatocystic Triangle and Triangle of Calot**

The hepatocystic triangle is formed by the proximal part of the gallbladder and cystic duct to the right, the common hepatic duct to the left, and the margin of the right lobe of the liver upward. The triangle originally described by Calot defined the upper boundary as the cystic artery. Within the boundaries of the triangle are a number of structures that must be identified before they are ligated or sectioned. The hepatocystic triangle contains the right hepatic artery (and sometimes an aberrant right hepatic artery), the cystic artery, and sometimes an accessory bile duct. The cystic artery usually arises from the right hepatic artery or an aberrant right hepatic artery within the hepatocystic triangle. At the neck of the gallbladder, the cystic artery divides into a superficial and a deep branch.

**Arterial Supply**

In general, the major blood vessels in the area of the extrahepatic biliary tree are posterior to the ducts, but in a number of cases they may lie anterior. The surgeon must recognize and preserve these arteries. The gallbladder is supplied by the cystic artery. Branches of the posterior superior pancreaticoduodenal artery supply the bile ducts and the retroduodenal and right and left hepatic arteries. Ischemia over more than 2 to 3 cm of the upper surface of the duct implies a high chance of biliary leakage. The major supply of the supraduodenal common bile duct originates...
from below the retroduodenal artery and in a small proportion of patients from the right hepatic artery. The bile ducts located in the hilum and the retropancreatic bile duct have an excellent blood supply.

**Venous Drainage**

Several cystic veins, rather than one, enter the hepatic parenchyma. A peripheral venous plexus helps the surgeon identify the common bile duct. Stripping of the common bile duct is not acceptable.

**Lymphatic Drainage**

Collecting lymphatic trunks from the gallbladder drain into the cystic node in the junction of the cystic and common hepatic ducts to the nodes of the hilum and posterior pancreaticoduodenal nodes. The pericholedochal nodes receive lymphatics from the extrahepatic bile ducts and from the right lobe of the liver.

**Spleen**

The spleen is covered at the left hypochondrium and is not palpable under natural conditions. It is associated with the posterior portions of the left 9th to 11th ribs and separated from them by the diaphragm and the costodiaphragmatic space. The upper third of the spleen is localized in relation to the lower lobe of the left lung, the middle third to the left costodiaphragmatic recess, and the lower third to the left pleura and costal origin of the diaphragm. The spleen shows two surfaces: the parietal and the visceral. The convex or parietal surface is related to the diaphragm, and the concave or visceral surface is related to the surfaces of the stomach, kidney, colon, and tail of the pancreas. On the visceral surface one finds the hilum, where the entrance and exit of the splenic artery form a tortuous path toward the spleen. The peritoneum covers the entire spleen with a double layer except for the hilum.

Understanding peritoneal reflections on this organ is essential for mastery of splenectomy. The gastrosplenic ligament divides at the hilum. The anterior sheet covers the surface of the spleen and reflects to the anterior surface of the left kidney. The posterior sheet encloses the splenic vessels and reflects to the dorsal peritoneum. The inferior part rests on the phrenicocolic ligament and is, if connected with this ligament, a common place for rupture of the capsule and bleeding. The abundant arterial vasculature of the spleen arises from the splenic artery, which runs tortuously along the upper border of the pancreas and ends in a number of smaller branches that vascularize the spleen. Two branches—the superior polar artery and the left gastroepiploic artery—have a unique appearance. The superior polar artery is one of the early branches of the splenic artery and divides into the short gastric vessels before entering the spleen. The left gastroepiploic artery, one of the most inferior branches of the splenic artery, vascularizes the greater curvature of the stomach and anastomoses with the right gastroepiploic artery. A plexus of large veins joins at the splenic hilum to form the splenic vein, which leads straight toward the portal vein after receiving the inferior mesenteric vein.

**Small Intestine**

It has been demonstrated that the length of the alimentary tract in humans is difficult to measure. An average a length of 6 to 6.5 m for the small intestine has been widely accepted. There is some evidence that intestinal length is greater in obese individuals. Generally speaking, surgeons are more concerned with the length of the intestine before extensive resection to prevent small bowel syndrome; therefore, before any bowel resection, a precise measurement should be made. Typically a 70% to 75% loss of small bowel will result in small bowel syndrome. Small bowel syndrome has also been defined as a bowel length of 100 to 120 cm of small bowel without colon, or 50 cm of small bowel with colon.

The mesentery of the small intestine has a length of 15 cm. It originates from the posterior abdominal wall and begins at the duodenojejunal junction, just to the left of the second lumbar vertebra. The mesentery passes downward toward the right sacroiliac joint. The mesentery contains the superior mesenteric vessels, along with lymphatics and lymph nodes. These drain the small intestine. There are a number of autonomic nerve fibers within the mesentery. The small bowel is divided into three sections. The first section is the duodenum, which is approximately 25 cm in length and extends from the pylorus to the duodenojejunal flexure; this point is marked by the ligament of Treitz. The duodenum is anatomically divided into four parts; it curves in the shape of the letter C around the head of the pancreas. At its origin the duodenum is covered with peritoneum for about 2.5 cm, after which it becomes a retroperitoneal organ. The upper half of the small intestine is called the jejunum and the remainder is the ileum. There is no obvious distinction between the two parts, and the division is one of convention only. However, the character of the small intestine does change as it courses distally toward the cecum. The jejunum has a thicker wall as the valvulae conniventes become larger and thicker. The proximal small bowel shows a greater diameter than the distal small bowel. Furthermore, the jejunum typically lies toward the umbilical region of the abdomen and the ileum toward the hypogastrum and pelvis. Mesenteric vessels tend to form fewer arcades in the jejunum, with long and relatively infrequent terminal branches passing to the intestinal wall. However, the ileum tends to be supplied by shorter and more numerous vessels that arise from a number of complete arcades.

**Blood Supply and Lymphatics of the Small Intestine**

The small intestine develops from the midgut and extends from the mid-duodenum to the distal transverse colon. It is supplied by the SMA, which arises from the aorta at the level of L1. The branches of the SMA include the following:

- The inferior pancreaticoduodenal artery, which supplies the pancreas and duodenum.
- Jejunal and ileal branches of the SMA; these give the blood supply to the bulk of the small intestine (Figs. 2.83).
- The ileocolic artery, which supplies the terminal ileum, the cecum, and the proximal part of the ascending colon. This also provides an appendicular branch to the appendix.
- The right colic artery, which supplies the ascending colon.
- The middle colic artery, which supplies the transverse colon to approximately two-thirds along its length. This vessel creates a division between the SMA and the IMA. The small intestine drains via the superior mesenteric vein and forms a confluence with the splenic vein to form the portal vein. This runs through the free edge of the lesser omentum and forms part of the superior border to the gastroepiploic foramen, before the portal vein continues to the liver.
The path of the lymph in the small bowel follows the vessels of the involved segment to the root of the superior mesenteric artery (SMA) near the head of the pancreas and to the extra peritoneum.

Large Bowel
The gastrointestinal tract ends at the colon, which is involved in absorption of water and electrolytes, mucous secretion, and the circulation and storage of feces. The colon measures approximately 150 to 180 cm in length and comprises nearly a fifth of the total intestinal length. It begins just distal to the terminal ileum at the ileocecal valve and extends to the dentate line, which includes the proximal two-thirds of the anal canal. Surgically, the colon terminates at the level of the levator ani muscles. The colon can be subdivided into the cecum, ascending colon, transverse colon, descending colon, sigmoid colon, and rectum. The caliber of the colon is largest at the cecum and gradually diminishes more distally toward the rectum, where it abruptly expands for storing feces. The colon is entirely surrounded by peritoneum, with the exception of the ascending colon, descending colon, and rectum.

Cecum and Appendix
The cecum measures approximately 5 to 7 cm in length and directly communicates with the terminal ileum at the ileocecal valve. The cecum can be partly or completely mobile along its mesentery, sometimes resulting in cecal volvulus. It is enveloped by peritoneum, but part of the posterior surface is connected to the iliac fascia via connective tissues and peritoneal folds along its medial and lateral aspects, forming the retrocecal fossa. The cecum does not have a separate mesocolon but shares the ileocolic mesentery that follows the course of the ileocolic vessels and lymph chain. The ileocecal valve enters the cecum as a line of protuberance typically arising from the posteromedial wall of the cecum. It delineates the junction between the cecum and ascending colon. The ileocecal valve has poorly developed musculature and consequently has deficient sphincteric function. In fact, a retrograde reflux of contrast into the small bowel from a barium enema can be easily seen. The appendix is a vestigial vermiform structure that can range from 2 to 20 cm in length (average length of 10 cm) and up to 6 mm in diameter. The appendix lies typically under the McBurney point, which can be defined along the caudal one-third of an oblique line joining the right anterior superior iliac spine and umbilicus. Its orifice lies at the cecal apex approximately 2 cm below the ileocecal valve. The position of the appendix can vary among individuals and may be retrocecal, or it may lie within the pelvic peritoneum. The appendix lies within its own short triangular mesocolon, denominated by the mesoappendix. The mesoappendix contains lymph nodes, arteries, and veins that supply and drain the appendix. The appendiceal orifice is typically visible at the coalescence of three longitudinal taeniae coli in the cecal tip.

Ascending Colon
The ascending colon measures 10 to 20 cm and lies within the anterior pararenal space. The ascending colon is a retroperitoneal structure covered only on its ventral and lateral surfaces by the posterior peritoneum. The adjacent peritoneum forms the paracolic gutters just lateral to the ascending and descending colon. The ascending colon is bordered posteriorly by the iliacus and quadratus lumborum muscles. More anteriorly, it is bordered by the greater omentum and small bowel loops. The ascending colon extends cranially to the caudal liver surface, where it is often referred to as the hepatic flexure. From there, it extends anteriorly toward the colic impression directly lateral to the gallbladder and makes a sharp left turn at the hepatic flexure, or junction between the ascending and transverse colon. At this point, the colon again becomes completely wrapped by peritoneum. The ascending mesocolon is not a real mesentery because it is not formed by two peritoneal layers suspending the colon. The ascending mesocolon follows the course of the ileocolic vessels and marginal vessels along the mesocolic side of the colon.

Transverse Colon
The transverse colon extends from the hepatic flexure and continues to the left abdomen, where it undergoes a sharp caudal turn at the most inferior aspect of the spleen to become the descending colon. The junction between the transverse and descending colon is often referred to as the splenic flexure. It is the longest and most mobile portion of the colon and may fold over and extend caudally to the level of the pelvis. It is suspended by the transverse mesocolon, which consists of two posterior peritoneal layers originating from the anterior peritoneal covering of the pancreas. The transverse colon is fastened from its superior surface to the greater curvature side of the stomach by the gastrocolic ligament. It is also attached directly to the diaphragm and spleen by the phrenicocolic ligaments (Fig. 2.84).

Descending Colon
The descending colon, similar to the ascending colon, is also retroperitoneal; it is covered along its anterior and lateral surfaces by peritoneum. It measures approximately 22 to 30 cm in length and is located within the anterior left pararenal space. The descending colon is predominantly fixed. It is smaller in caliber and more posteriorly situated on the opposite side of the ascending colon. The caudal portion of the descending colon just distal to the iliac crest sits in the left iliac fossa and is often referred to
as the iliac colon. Similar to the ascending colon, the descending colon does not have a true mesentery. Its mesocolon attaches medially to connective tissue anterior to the aorta and contains the inferior mesenteric vein and mesocolic marginal vessels.

**Sigmoid Colon**

The S-shaped sigmoid measures on average 40 cm. It is entirely covered by peritoneum and is suspended by the sigmoid mesocolon. The sigmoid extends from the pelvic brim to approximately the third sacral vertebra and is often tortuous and redundant. It extends caudally to transition into the rectum. The sigmoid mesocolon root has a V-shaped attachment along the external iliac vessels, iliac bifurcation, and third segment of the sacrum. The sigmoid mesocolon follows the course of the superior hemorrhoidal vessels and mesocolic marginal vessels of the descending colon. The sigmoid colon is often seen within the abdomen because of its increased mobility and redundant loops.

**Rectum**

The rectum measures 12 cm on average and continues caudally from the sigmoid colon to terminate at the anal canal. The proximal one-third of the rectum is retroperitoneal and relatively fixed. Only the anterior and lateral surfaces of the proximal one-third of the rectum are covered by peritoneum; the peritoneum reflects laterally to form the pararectal fossae, allowing for lateral rectal distention for storage of feces. The distal one-third of the rectum is entirely extraperitoneal with no peritoneal interface. The rectum dilates distally at the rectal ampulla, which holds feces just before defecation. The rectum transitions into the anal canal at the anorectal line. Surgeons typically use the levator ani muscles to demarcate the rectum and anus because the anorectal line is not routinely visualized during surgery. The rectum has no haustra; the longitudinal taeniae coli terminate at the rectosigmoid junction, and the rectum continues solely as a circular smooth muscle layer. One to four prominent semilunar plicae, referred to as the rectal valves, are present in most individuals. They may vary in size, number, and location. These valves may serve as anatomic landmarks for localizing lesions within the rectum.

**Anal Canal**

The anal canal measures 2.5 to 4 cm in length. It is entirely extraperitoneal and begins distal to the rectal ampulla at the anorectal line. The internal anal sphincter, external anal sphincter, and levator ani muscles surround it. It contains several columns, or ridges, that contain the terminal branches of the rectal arteries and veins. The anorectal line is localized at the highest aspect of these ridges. Multiple anal glands are present along the caudal aspect of the anal columns. They are responsible for secreting lubricating mucus during defecation. The dentate or pectinate line demarcates the junction of the cranial and caudal anal canal. This difference in embryologic origin explains the differences in vascular supply and lymphatic drainage of the cranial and caudal anal canal. The epithelial layer transitions from columnar epithelium to stratified squamous epithelium at the dentate line. It also demarcates the end of the colon. The anal canal ends at the anus, or external outlet of the gastrointestinal tract.

**Blood Supply to the Large Bowel**

- The appendix receives its blood supply from the appendicular artery arising from distal ileocolic arterial branches that are contained in the mesoappendix. Lymphatics from both the cecum and appendix drain into the mesoappendix and ileocolic lymph chains along the ileocolic artery and to the superior mesenteric lymph nodes.
- The ileocolic and right colic arteries arising from the SMA supply the cecum and ascending colon.
- The middle colic artery arises from the SMA and supplies the transverse colon. The transverse colon also receives blood from arcading vessels from the right and left colic arteries. The splenic flexure is supplied by the middle colic artery or by the left colic artery arising from the IMA (Fig. 2.85).
- The left colic artery supplies most of the descending colon.
- The respective colic arteries and veins supply the marginal artery of Drummond, which consists of an arcade of vessels arising from the ileocolic, right colic, middle colic, left colic, and sigmoid arteries. It essentially courses parallel to the entire mesocolic border of the large intestine. The marginal arteries and veins then terminate in small vasa recta branches that penetrate and supply or drain the colonic surface and epiploic appendages.
- Several ascending and descending branches of sigmoid arteries also arising from the IMA supply the sigmoid colon. The single superior rectal artery, or hemorrhoidal
artery, is the distal continuation of the IMA and supplies the proximal rectum and anus to the level of the dentate line (Fig. 2.86).

- The middle rectal artery typically arises directly from or from branches of the internal iliac artery.
- The paired inferior rectal arteries arise off the internal iliac branches of the internal pudendal arteries and supply the distal one-third of the anus caudal to the dentate line and the distal rectum.
- Varicosities of the respective internal and inferior rectal veins form internal and external hemorrhoids, respectively.

The splenic flexure and rectosigmoid colon represent regions of relatively reduced perfusion volume because of their location at the junctions of major vascular territories. These regions are presumed to have worse marginal artery communication and are referred to as “watershed” regions of the colon. Accordingly, these regions are more vulnerable to hypovolemic ischemic injury. The anastomosis between the right colic and ileocolic arteries is lacking in a small percentage of the population. The meandering artery of Riolan arises off the middle colic artery or SMA and communicates with the IMA or left colic artery in 10% of the population. It can work as a collateral route for blood supply either to or from the SMA in the event of SMA branch or IMA branch occlusion, respectively.

Venous drainage occurs directly parallel to the corresponding colic arteries. Specifically, the ileocolic and right colic veins drain the cecum and ascending colon, respectively. They then drain into the superior mesenteric vein of the portal venous system. The transverse colon venous drainage also occurs through the superior mesenteric vein. Venous drainage of the descending and sigmoid colon is via the inferior mesenteric veins.

The lymphatic drainage of the ascending colon is via the paracolic and epiploic lymph nodes to the superior mesenteric lymph nodes. The lymphatic drainage of the transverse colon progresses from the middle colic to the superior mesenteric lymph node chains. Lymphatic drainage of the descending and sigmoid colons occurs via intermediate colic lymph nodes along the left colic artery to the inferior mesenteric lymph nodes. Rectal venous and lymphatic drainage occurs via superior, middle, and inferior rectal veins and lymphatic chains. The superior rectal vein drains into the portal venous system via the inferior mesenteric vein, whereas the middle and inferior rectal veins drain into the systemic venous systems via internal iliac veins. The submucosal rectal venous plexus consists of the internal rectal venous plexus just deep to the rectal epithelium and the external rectal venous plexus external to the rectal muscular wall. Lymphatics from the superior rectum drain with the superior rectal vessels to the pararectal lymph nodes and continue in the paraduodenal mesenteric, inferior mesenteric, and finally, lumbar lymph nodes. The inferior rectal lymph drainage ascends along with the middle rectal arteries and empties into the internal iliac lymph node chain. As previously discussed, the anal canal is supplied by branches of the superior rectal artery at the level proximal to the dentate line. The inferior rectal arteries supply the anal canal distal to the dentate line. The proximal anal canal is drained by the superior rectal vein, which later drains into the inferior mesenteric vein and portal venous system. The distal anal canal is drained by the middle and inferior rectal veins, which drain into the internal iliac vein and IVC of the systemic venous system. The anastomoses between the superior, middle, and inferior rectal veins provide a communication between the portal and systemic venous systems. Lymphatic drainage in the proximal anal canal progresses through the internal iliac, common iliac, and lumbar lymph node chains. Lymphatic drainage in the distal anal canal occurs via superficial inguinal lymph nodes.

**Conclusion**

Surgical anatomy is of paramount importance to all who treat women with gynecologic malignancies. A detailed understanding of such anatomy not only will enhance the surgeon’s ability to master complex and difficult procedures but will also help decrease inadvertent complications during the course of surgery. All great students of anatomy will have reached their full potential once they have dedicated countless hours to learning the art of what the human body truly is: an intricate and detailed labyrinth of complex and sophisticated architecture.

**Suggested Readings**


Barber D, Brubaker L, Eckler K. In: Post TW, ed. Surgical Female Urogenital Anatomy: UpToDate. UpToDate, Waltham, MA.

Barber D, Park AJ, Sharp HT, Eckler K. In: Post TW, ed. Surgical Female Pelvic Anatomy: UpToDate. UpToDate, Waltham, MA.


Enhanced Recovery After Surgery (ERAS) is a multimodal perioperative care pathway to improve functional rehabilitation after a surgical procedure, reducing the patient’s stress response in reaction to the operation and postoperative catabolism. The concept was first introduced by Kehlet, who suggested that a focus on early postoperative rehabilitation and nutrition, use of regional analgesia, and avoidance of recovery-limiting procedures (e.g., liberal use of intravenous [IV] fluids, placement of a urinary bladder catheter and drains) might lead to accelerated recovery and reduced postoperative morbidity and costs. In terms of costs, the use of ERAS has resulted in a mean savings of $2245 (€1651) per patient. The program includes a set of elements that are evidence-based modifications of traditional perioperative patient care, but it is a true change of paradigm in the care of surgical patients. The number of ERAS elements varies, but approximately 20 items are included in most programs. In 2010 the ERAS Society was officially founded. Since then, several sets of guidelines have been published to expand ERAS programs in different specialties, and so far such implementations have demonstrated the efficacy of ERAS in postoperative recovery. The main goals of ERAS programs described to date are to reduce the length of hospital stay after a surgical procedure and to “speed” patients’ return to normal daily activities without increasing complications, readmission rates, or cost. To achieve these goals, ERAS programs focus primarily on reduction of perioperative stress, achievement of satisfactory pain control, resumption of normal gastrointestinal function, and early mobilization. The Royal College of Obstetricians and Gynaecologists has suggested that ERAS programs offer safe, high-quality perioperative care and should become standard practice for all women undergoing elective gynecologic surgical procedures.

The aim of this chapter is to describe what an ERAS program is, with gynecologic oncology as the main focus of the discussion. For this purpose, the evidence that has been published so far in gynecologic oncology is outlined; every component of an ERAS pathway is described; and a focus summary of the recommendations based on the ERAS Society Gynecologic Oncology guidelines, Part I and Part II, is provided.

Data on the incorporation of ERAS programs in gynecologic oncology are limited. In 2006, one of the first publications that evaluated accelerated recovery in gynecologic oncology was published by Marx and co-workers, who evaluated 72 patients undergoing laparotomy for ovarian cancer. Patients were divided into two groups according to whether they received “traditional” care or underwent “multimodal rehabilitation” (no bowel preparation, prophylactic postoperative nausea and vomiting [PONV] medication, early mobilization, early removal of drains and urinary catheter, early oral intake, opioid-restrictive analgesia, and routine use of laxatives). The authors reported that the median postoperative stay was reduced from 6 days in group 1 (mean, 7.3 days) to 5 days in group 2 (mean, 5.4 days) ($P < .05). There were no differences in complication rates ($P < .01), and the readmission rates were higher in the traditional care group ($P < .05). In another study, Chase and co-workers retrospectively evaluated 880 gynecologic patients who underwent laparotomy (48% had a final pathologic assessment consistent with malignancies) with an ERAS program (called in the study “postoperative clinical pathway”). The most common cancer was endometrial (66%). Forty percent of the procedures performed were categorized as radical and/or staging procedures. The ERAS program consisted of preoperative counseling; no fluid overload in the intraoperative and postoperative settings; early mobilization; early removal of drains, lines, and urinary catheters; early oral intake; and opioid-sparing analgesia. The median length of hospital stay was 2 days (range, 0–52 days). The readmission rate was 5% (44/880), no reoperations were reported, and 7% (59/880) of patients had a complication (most commonly ileus). The complication rates were comparable or decreased when compared with those of other studies in the literature. The authors concluded that these clinical pathways reduced the length of hospital stay without increasing morbidity or mortality after laparotomy for suspected gynecologic malignancy.

Gerardi and co-workers evaluated an ERAS pathway in gynecologic oncology patients who underwent a rectosigmoid colectomy as part of their surgical treatment for advanced...
ovarian and primary peritoneal cancers. A total of 64 patients were included in the study and were divided into two groups: those who received ERAS perioperative care (group A; n = 19 patients) and a control group (group B; n = 45 patients). The ERAS elements included in this study were (1) early removal of drains, lines, and urinary catheters and (2) early oral intake. Although the median time to flatus was equivalent between groups, median time to tolerance of regular diet was significantly shorter in the clinical pathway group (ERAS) than in the conventional treatment group (3 vs. 6 days, respectively; \( P = .013 \)). Patients in group A had a median length of stay (LOS) of 7 days, compared with 10 days for patients in group B (\( P = .014 \)). The median total hospital cost of postoperative care for patients in group A was $19,700, compared with a median total cost of $25,110 for patients in group B, with a median reduction in hospital cost of $5410 per patient with implementation of the clinical pathway. There was no difference in the 30-day readmission rate (group A, 21%; group B, 33%; \( P = .379 \)).

Carter et al. reported a review of a total of 389 patients who underwent laparotomy for a suspected or confirmed preoperative cancer diagnosis. The study included the majority of the 22 ERAS elements (preoperative counseling; minimization of fasting period; no bowel preparation; multimodal analgesia; no fluid overload; no routine drains; early mobilization; early removal of drains, lines, and urinary catheters; early oral feeding; balanced multimodal opioid-restrictive regimen; and routine use of laxatives). A total of 227 (58%) had cancer (51% ovarian, 39% endometrial, and 9% cervical). The surgical procedures were deemed to be complex in 348 patients (89%), with lymph node sampling or dissection performed in 68 of them (17%). The median length of hospital stay was 3 days, with a readmission rate of 4% and a reoperation rate of 0.5%. Twenty-eight percent of the patients were discharged on postoperative day 2. There were no differences in LOS according to the type of cancer or even if the final pathology report confirmed benign disease. In addition, the study evaluated the impact of program experience and the appointment of a clinical nurse consultant. The authors found that increasing program experience was associated with an improvement in the percentage of patients discharged on day 2 from 10% in the first year to 36% in the fifth year of the program.

A previously published study on ERAS in gynecologic oncology, by Kalogerα and co-workers, was a retrospective comparison between an ERAS program and conventional care in women undergoing major abdominal surgical procedures for gynecologic malignancies or vaginal reconstructive procedures for pelvic organ prolapse. A total of 241 women in the ERAS group (81 cytoreductive, 84 staging, and 76 vaginal surgeries) were compared with 235 women in the conventional care group. In that study, postoperative nausea (55.6% vs. 38.5%, \( P = .031 \)) and vomiting (17.3% vs. 2.6%, \( P = .002 \)) were more frequent in the ERAS group than in the control group. The authors attributed these results to the fact that 40% of patients in the case group had undergone a large bowel resection. Despite this increase in nausea and vomiting, women in the case group had a return of bowel function 1 day earlier than the control group (\( P = .001 \)), and the rate of postoperative ileus was no different between groups. Eighty-seven percent of patients rated their satisfaction with nausea and vomiting control as excellent or very good, suggesting that early feeding overall is well tolerated. Women in the ERAS group had a median time to return of bowel function 1 day less than the time in the control group (\( P < .001 \)) without differences in postoperative ileus. Median length of hospital stay was 4 days less in the ERAS group than in the control group (8.7 ± 7.6 days vs. 11.9 ± 11.9 days, \( P < .001 \)). Almost half (46.1%) of the patients in the ERAS group were discharged the day after the operation, compared with only 6.5% of women in the control group. The rates of readmission and postoperative complications were no different between the groups. The ERAS program was associated with a 30-day cost savings of more than $7600 per patient (18.8% reduction). In addition, 95% of patients in the ERAS group rated their care as excellent or very good (patient satisfaction surveys were not available in the control group). The authors concluded that implementation of an ERAS program was associated with acceptable pain management, reduced LOS with stable readmission and mortality rates, adequate patient satisfaction, and substantial cost reductions.

A Cochrane review of perioperative ERAS programs for gynecologic cancer patients published in 2012 and subsequently updated in 2015 concluded that there was no evidence to support or refute the use of an ERAS program; however, the authors recognized that this was likely due to the lack of prospective randomized trials and went on to discuss the benefits shown in the nonrandomized studies.

In 2014, Nelson and co-workers published a comprehensive review of the literature regarding ERAS programs in gynecologic oncology. The authors analyzed seven reports and found significant improvements in patient satisfaction, LOS (up to 4 days), and cost (up to $7600 in savings per patient) in ERAS programs compared with historical controls. They also found that morbidity, mortality, and readmission rates were no different between groups. The subject of physician and patient acceptance of ERAS programs was also addressed in a recent publication. Hughes and colleagues published a survey that assessed the perceptions of care providers and patients on the relevance and importance of an ERAS program. In that study, preoperative and postoperative surveys were completed by patients who underwent major hepatic, colorectal, or esophageal procedures. A total of 109 patients and 57 care providers completed the preoperative survey. Freedom from nausea and pain at rest were the care components rated highest by both patients and care providers. Further data are needed pertaining to overall acceptance of ERAS programs and patient-reported outcomes.

A point of interest to surgeons is whether the benefits obtained from use of an ERAS program in gynecologic oncology patients undergoing open surgical procedures would also be achieved in patients undergoing minimally invasive procedures. This question arises from the well-known premise that minimally invasive surgical procedures offer benefits in terms of shorter LOS and fewer complications compared with their open counterparts.

Chapman and co-workers performed a retrospective case-control study including 165 patients undergoing robotic or laparoscopic gynecologic oncology procedures. Fifty-five patients received care according to an ERAS program, and 110 were historical controls. The ERAS elements included in the study were carbohydrate loading, no bowel preparation, opioid-sparing pain medications, PONV medication, transverse abdominis plane (TAP) block (a peripheral nerve block designed to anesthetize the nerves supplying the anterior abdominal wall, T6–L1) or IV lidocaine, no fluid overload, ambulation and removal of urinary catheter 6 hours after operation, and early regular diet. ERAS patients were significantly more likely to be discharged on postoperative day 1 than patients in the control group (91% vs. 60%,
respectively; \( P < .001 \)). The median LOS for ERAS patients was 30 hours (interquartile range, 30–54 hours) compared with 34 hours (interquartile range, 27–32) for historical control patients \( (P < .01) \). Hospital costs for patients were on average $1810 less than for historical control patients ($13,771 compared with $15,649; \( P = .01 \)), representing a 12% decrease in overall cost. Opioid use decreased by 30% in the ERAS group compared with patients in the control group (31 vs. 44 mg of IV morphine equivalents, \( P < .01 \)), and the authors also reported significantly lower mean postoperative pain scores (visual analog scale score 2.6 vs. 3.12 on postoperative day 1, \( P = .03 \)). No ERAS patient required patient-controlled analgesia or received epidurals. Readmission rates did not differ between groups \( (P = .53) \). No patients in either group required reoperation. In conclusion, the authors argued strongly in favor of instituting this low-cost, low-risk intervention as a standard part of perioperative care in patients undergoing minimally invasive procedures.

### Elements of ERAS Program and Guidelines

The elements of a standard ERAS program and measures of compliance are presented here as outlined and followed by the Department of Gynecologic Oncology and Reproductive Medicine at MD Anderson Cancer Center. The program’s core elements are divided into three groups: preoperative, intraoperative, and postoperative (Fig. 3.1). It should be noted that all programs include all elements of ERAS, and there remains some debate in the literature and among ERAS teams as to which are the absolutely crucial elements for successful outcomes. Emphasis is given to the elements that are present in most studies and in the two sets of ERAS guidelines (Part I and Part II) published in 2016 by the ERAS Society (Tables 3.1–3.3).

#### Preoperative Components

##### Preoperative Counseling

Preoperative counseling helps to set expectations about surgical and anesthetic procedures, fatigue, and pain and to diminish fear.\(^{19}\) Information should be given to patients not only on the details of the procedure but also on what the patient can expect during recovery. Most studies show that counseling provides beneficial effects with no evidence of harm.\(^{20}\)

- It is recommended that patients routinely receive dedicated preoperative counseling.

#### Preoperative Optimization

It is generally accepted that preoperative medical optimization is necessary before surgical procedures. Use of tobacco and alcohol should be routinely assessed preoperatively because they

![FIG. 3.1 Elements of Enhanced Recovery After Surgery pathway. PONV, postoperative nausea and vomiting.](image-url)
TABLE 3.2 Intraoperative Components

<table>
<thead>
<tr>
<th>Component</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short-acting anesthesia</td>
<td>Short-acting anesthetic agents should be used to allow rapid awakening</td>
</tr>
<tr>
<td>Maintenance of normothermia</td>
<td>Maintenance of normothermia with active warming devices should be used routinely</td>
</tr>
<tr>
<td>No drainage of the peritoneal cavity or nasogastric intubation</td>
<td>Avoidance of routine drainage of the peritoneal cavity and nasogastric tube (NGT) placement. NGT inserted during a surgical procedure should be removed before reversal of anesthesia</td>
</tr>
<tr>
<td>Avoidance of salt and water overload</td>
<td>Goal-directed fluid therapy (restrictive or liberal fluid regimens should be avoided)</td>
</tr>
<tr>
<td>Minimally invasive procedures</td>
<td>Should be the selected approach when possible</td>
</tr>
</tbody>
</table>

TABLE 3.3 Postoperative Components

<table>
<thead>
<tr>
<th>Component</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postoperative nausea and vomiting (PONV) prophylaxis</td>
<td>Patients should receive prophylaxis using a multimodal approach to PONV that includes more than two antiemetic agents</td>
</tr>
<tr>
<td>Nonopioid oral analgesia or multimodal analgesia</td>
<td>Multimodal approach to analgesia (nonsteroidal antiinflammatory drugs [NSAIDs] or acetaminophen, gabapentin, and dexamethasone [unless contraindications exist])</td>
</tr>
<tr>
<td>Avoidance of salt and water overload</td>
<td>Intravenous fluids discontinued on postoperative day 1; balanced crystalloid solutions are preferred to 0.9% normal saline</td>
</tr>
<tr>
<td>Early oral nutrition</td>
<td>Regular diet within the first 24 h after gynecologic oncology surgical procedures</td>
</tr>
<tr>
<td>Removal of urinary catheter</td>
<td>Urinary catheter should be removed within 24 h postoperatively</td>
</tr>
<tr>
<td>Early mobilization</td>
<td>Early mobilization within 24 h of surgical procedure</td>
</tr>
<tr>
<td>Postoperative glucose control</td>
<td>ERAS elements that reduce metabolic stress should be employed to reduce insulin resistance and the development of hyperglycemia. Glucose levels above 180–200 mg/dL should be treated with insulin infusions and regular blood glucose monitoring to avoid the risk of hypoglycemia</td>
</tr>
<tr>
<td>Audit of compliance and outcomes</td>
<td>Audit of compliance should be done regularly</td>
</tr>
</tbody>
</table>

Preoperative Mechanical Bowel Preparation

Mechanical bowel preparation (MBP) is not routinely recommended because it has been associated with patient distress, may cause dehydration, and is associated with prolonged ileus. A Cochrane review of 18 randomized clinical trials (5805 patients) found no statistically significant evidence that patients benefit from either bowel preparation or rectal enemas. There were no differences in infection rates in patients with and without bowel preparation (odds ratio [OR], 1.16; 95% confidence interval [CI], 0.95–1.42), and the rate of anastomotic leak was 4.4% for patients with bowel preparation and 4.5% for those without (OR, 0.99; 95% CI, 0.74–1.31). In patients undergoing minimally invasive procedures, the routine use of MBP has not been shown to improve intraoperative visualization, bowel handling, or ease of performing the procedure.

A 2014 Cochrane review regarding antibiotic use in patients undergoing colorectal surgical procedures included 260 trials and 43,451 patients. The authors of that review concluded that there is high-quality evidence showing that antibiotics covering aerobic and anaerobic bacteria delivered orally or intravenously (or both) before elective colorectal surgical procedures can reduce the risk of postoperative surgical wound infection by as much as 75%. Also, the study revealed that there is no need for a second intraoperative dose or any postoperative doses when the antibiotic is being given for prophylaxis alone and that additional administration may increase the risk of resistant organisms and Clostridium difficile colitis. It appears that a combination of both routes of administration (oral and IV) results in the greatest decrease in risk of surgical site infection (SSI). Currently, the preponderance of the evidence regarding MBP favors avoiding the routine use of MBP.

One question that remains unanswered pertains to whether preoperative oral antibiotics (OAs) reduce SSI after bowel operations when MBP is not used. Two retrospective studies have addressed this subject. In the first study, Cannon and co-workers analyzed Veterans Affairs Surgical Quality Improvement Program preoperative risk and SSI outcome data linked to Veterans Affairs Surgical Care Improvement Project and Pharmacy Benefits Management Services data including 9940 patients. Colonic and rectal procedures were included. For the analysis, patients were categorized into four groups (MBP alone, MBP with preoperative OAs, no MBP and no OAs, and no MBP with OAs). The authors found that the use of OAs, with or without MBP, resulted in a significant decrease in SSI in comparison with no boweler preparation alone (9.0% vs. 18.1%, P < .0001). There was no significant difference in the SSI rates between those receiving OA alone and those receiving OA plus MBP (8.3% vs. 9.2%, P = .47). Those receiving no bowel preparation...
had SSI rates similar to those in patients who had MBP only (18.1% vs. 20%), regardless of OA use. In an adjusted analysis, the use of OA alone was associated with a 67% decrease in SSI rates (OR, 0.33; 95% CI, 0.21–0.50). The second study, published by Atkinson and co-workers, used the National Surgical Quality Improvement Program database. This study included 6399 patients who underwent elective segmental colectomy without MBP. The authors concluded that the incidence of SSI differed substantially between patients who had received OAs and those who had not (9.7% vs. 13.7%, \( P = .01 \)). When confounding factors are controlled for, the use of preoperative OAs decreased the incidence of SSI rates (OR, 0.66; 95% CI, 0.48–0.90; \( P = .01 \)).

- Routine oral MBP is not recommended for gynecologic oncology patients, including those with a planned bowel resection.

OAs should be used before an operation when it is known in advance that the patient will undergo a bowel procedure. There is no need to use MBP. A combination of neomycin and metronidazole is a valid option. Neomycin is given at a dose of 500 mg orally at 9:00 p.m. and 11:00 p.m. the night before the operation, and metronidazole is also given at a dose of 500 mg orally at 9:00 p.m. and 11:00 p.m. the night before the procedure.

**Preoperative Fasting and Carbohydrate Loading**

Prolonged fasting is associated with insulin resistance, which in turn is associated with increased morbidity, mortality, and length of hospital stay. To attenuate these, diminished fasting and carbohydrate drinks are recommended for patients undergoing major abdominal surgical procedures. Scientific evidence has shown that intake of clear fluids until 2 hours before an operation does not increase gastric contents, reduce gastric fluid pH, or increase complication rates. Caution must be implemented in diabetic patients, particularly those with diabetic neuropathy, given that such patients may have delayed gastric emptying for solids, thereby possibly increasing their risk of regurgitation and aspiration. One must note that patients with uncomplicated type 2 diabetes mellitus have normal gastric emptying.

Carbohydrate loading before surgical procedures has been advocated to achieve a metabolically fed state, reducing postoperative insulin resistance. In a meta-analysis including 27 randomized controlled trials (RCTs) (1976 patients) evaluating the effects of preoperative carbohydrate treatment on patients undergoing elective procedures, the authors demonstrated a significant reduction in LOS among patients undergoing major open abdominal operations. Preoperative carbohydrate treatment was safe (no occurrence of drink-related complications) and was associated with reduced development of postoperative insulin resistance without an increase in postoperative complications. Aspiration pneumonitis was not reported. \(^{38}\) ERAS guidelines recommend 400 mL of a 12.5% carbohydrate–containing clear drink with a proven safety profile until 2 hours before anesthesia. \(^{39}\) Both laparoscopic and minor surgeries are associated with minimal development of insulin resistance and low complication rates, and an intervention such as preoperative carbohydrate loading would not be expected to improve clinical outcomes in this group of patients. Hence, in patients without conditions associated with delayed gastric emptying, the intake of clear fluids until 2 hours before the induction of anesthesia as well as a 6-hour fast for solid food is recommended. \(^{40}\)

- Clear fluids should be allowed for up to 2 hours and solids for up to 6 hours before induction of anesthesia.
- Carbohydrate loading should be considered because it reduces postoperative insulin resistance and increases overall patient satisfaction.

**Preanesthetic Medication**

Routine administration of long-acting sedatives to decrease anxiety within 12 hours of a surgical procedure should be avoided owing to the effects of these sedatives on immediate postoperative recovery. Among the most common effects are somnolence, sedation, confusion, dysarthria, ataxia, vertigo, and stomach discomfort. The use of short-acting anxiolytics for severe preoperative anxiety may be appropriate on a case-by-case basis. When patients are appropriately informed and prepared for an operation, they exhibit suitably low levels of stress before elective procedures. \(^{42,43}\)

- Routine administration of sedatives to reduce anxiety preoperatively should be avoided.

**Thromboembolism Prophylaxis**

The risk of venous thromboembolic events (VTEs) among patients undergoing surgical procedures for cancer is two-fold to threefold higher than in patients without cancer. Venous thromboembolism is a major risk in gynecologic oncology patients, with rates as high as 8% in endometrial cancer \(^{45}\) and 38% in ovarian cancer. \(^{46}\) All gynecologic oncology patients undergoing major surgical procedures (i.e., longer than 30 minutes) should receive VTE prophylaxis with either low-molecular-weight heparin (LMWH) or heparin. \(^{47}\) Prophylaxis should be commenced preoperatively, combined with mechanical methods, and continued postoperatively. \(^{44}\) Pneumatic compression stockings reduce the rate of VTE when compared with observation within the first 5 days postoperatively. \(^{48}\) Their efficacy is equivalent to that of heparin and improved when combined with heparin. \(^{50}\) in gynecologic oncology patients. Combined oral hormonal contraception is a risk factor for postoperative thromboembolism. The risk of thromboembolism varies according to progesterone type. There is lower risk with levonorgestrel, norethisterone, and norgestimate. Women should be encouraged to use an alternative form of contraception preoperatively. Continued use of combined oral hormonal contraception is an indication for thromboprophylaxis. \(^{51,52}\)

With regard to long-term thromboprophylaxis, a large prospective cohort trial showed an increased rate of VTE within 30 days of operation in patients with cancer, \(^{53}\) and extended prophylaxis (28 days) is considered the standard of care in such patients. \(^{54}\) A Cochrane review of four RCTs examining extended prophylaxis showed a decrease in overall VTE (14.3% vs. 6.1%; \(P < .0005\)) and a decrease in symptomatic VTE (1.7% vs. 0.2%; \(P = .02\)). \(^{55}\) Extended prophylaxis in minimally invasive procedures is likely not necessary without other high-risk features (elevated body mass index [BMI], previous VTE, coagulopathy, decreased mobility). \(^{56}\)

- Patients at risk of VTE should receive prophylaxis with either LMWH or heparin, commenced preoperatively, combined with mechanical methods.
- Extended prophylaxis (28 days) should be given to patients after laparotomy for abdominal or pelvic malignancies.
- Patients should discontinue oral contraception before surgical procedures and switch to another form.
Antimicrobial Prophylaxis
SSIs in gynecology involve skin flora, vaginal flora, or enteric bacteria when the colon is entered. Prophylactic antibiotics should therefore include broad-spectrum antibiotics such as cephalexin (cefazolin) or amoxicillin–clavulanic acid. For patients allergic to penicillin or cephalosporins, a combination of clindamycin and gentamicin given intravenously or a quinolone can be used. The benefits of antibiotic prophylaxis in reducing SSIs after vaginal or abdominal hysterectomy have been documented. Antibiotics should be administered intravenously within 1 hour before skin incision (usually at the time of anesthesia induction). The dose should be increased in obese patients (BMI >35 or weight >100 kg) and repeated after one to two times the half-life of the chosen medication in prolonged operations (e.g., 3 hours for cefazolin, half-life 1.8 hours) and in case of blood loss of more than 1500 mL.
• IV antibiotics (first-generation cephalosporin or amoxicillin–clavulanic acid) should be administered routinely within 60 minutes before skin incision; additional doses should be given during prolonged operations, with severe blood loss, and in obese patients.

Intraoperative Components
Short-Acting Anesthesia
The anesthesia technique should allow rapid awakening, although it should be maintained with short-acting agents such as sevoflurane or desflurane or continuous target-controlled infusions of propofol. Although intraoperative opioids should be avoided, in certain settings they are still frequently used, and in such circumstances the best choice is continuously infused remifentanil (effects are limited to several minutes after the completion of the infusion). Total intravenous anesthesia (TIVA) with propofol or volatile anesthetics (sevoflurane or desflurane) should be chosen. Propofol-based total IV anesthesia has fewer postoperative side effects and the advantage of producing less PONV. The doses of the drugs used should be tailored individually. The recommended muscle relaxant is rocuronium because it acts for approximately 60 minutes after the induction dose and for 15 minutes after the maintenance dose and its effect can be quickly reversed (by using neostigmine or sugammadex). Use of the bispectral index (BIS), a monitoring parameter for depth of anesthesia, may allow reduction of anesthetic dose and hence facilitate rapid awakening. Regional anesthetic techniques are opioid sparing, reducing PONV and allowing more rapid awakening. Studies have shown a reduction in pulmonary complications when a lung-protective ventilation strategy is used (tidal volumes of 5–7 mL/kg with a positive end-expiratory pressure [PEEP] of 4–6 cm H₂O).
• Short-acting anesthetic agents should be used to allow rapid awakening.
• A ventilation strategy involving tidal volumes of 5 to 7 mL/kg with a PEEP of 4 to 6 cm H₂O should be used to reduce postoperative pulmonary complications.

Multimodal Opioid-Sparing Regimens
Anesthesia is not limited to the surgical procedure; it also involves the management of postoperative pain. In open procedures, the use of epidural analgesia has proven to be superior to opioid-based alternatives for several important outcomes, including pain, PONV, and complications. The use of thoracic epidural analgesia remains a topic of debate, given that it has been proposed to potentially delay the recovery of the patient by increasing the time to Foley catheter removal and ambulation. The authors have chosen not to use routine epidurals because these can be associated with longer anesthesia preparation time, longer time to first ambulation, and hypotension. Given that most of the data on the benefits of epidural analgesia were not obtained in the setting of gynecologic oncology patients and the fact that these elements may all work toward detracting from the principle of faster recovery, the use of epidural analgesia is not routinely recommended. Wound infiltration with bupivacaine is routinely performed before closure of the abdominal wall incision.
• A multimodal analgesia strategy should be used with the aim of reducing the postoperative opioid requirement. Wound infiltration should be used if available. Dexamethasone is recommended for pain control and to prevent PONV.

Maintenance of Normothermia
Hypothermia has been shown to impair drug metabolism, adversely affect coagulation, and increase bleeding and cardiac morbidity. Wound infections are significantly less common with the use of active warming compared with conventional methods, with an absolute risk reduction of 13%. A reduction in body temperature during surgical procedures leads to the development of postoperative tremors, which substantially increase the metabolic requirements of the body and oxygen consumption and can worsen pain. It is important to maintain normothermia by active methods throughout the perioperative period, including prewarming patients to avoid an initial drop in body temperature. During the operation, IV fluids should be warmed to avoid lowering body temperature, and active warming with warm air blanket devices should be used. Warming should be continued into the postoperative period to ensure the patient leaves the postanesthesia care unit with a temperature higher than 36.0°C.
• Maintenance of normothermia with suitable active warming devices and warm fluids should be used routinely.

No Routine Nasogastric Intubation or Drainage of the Peritoneal Cavity
Nasogastric decompression does not reduce the risk of wound dehiscence or intestinal leaks and moreover increases the risk of postoperative pneumonia (6% vs. 3%) after elective abdominal procedures. In a prospective randomized trial comparing early feeding with nasogastric decompression after major open gynecologic oncology procedures, the authors found no significant difference in PONV between the two groups. Time to passage of flatus and length of hospital stay were significantly shorter in the early-feeding group. For gastric perforation to be minimized during the insertion of the Veress needle during minimally invasive procedures, an orogastric drain can be beneficial, but it should be removed before reversal of anesthesia. Routine use of abdominal drains is based on the rationale that they reduce perioperative fluid collections and are useful in the early detection of postoperative complications such as bleeding or anastomotic leakage. However, it has been shown that the only clinical scenario in which drains may have a potential benefit is in the setting of very low anterior resections (defined as anastomosis within 6 cm from the anal verge).
• Use of abdominal drainage should be minimized. In the setting of low anterior resections, drainage use should be left to the surgeon’s discretion.
• Routine nasogastric intubation should be avoided. Nasogastric or orogastric tubes inserted during an operation should be removed before reversal of anesthesia.
Avoidance of Salt and Water Overload

A key component of the intraoperative period of an ERAS program is the use of goal-directed fluid therapy, defined as the use of minimally invasive hemodynamic monitors to detect flow-related parameters and/or dynamic parameters of fluid responsiveness in order to titrate therapeutic interventions (IV fluids and/or inotropic therapy administration) and optimize end-organ tissue perfusion. Whereas salt and fluid overload in the perioperative period is a major cause of morbidity, very restrictive fluid regimens also lead to increased morbidity and mortality. It is important to initiate fluid restriction in the intraoperative setting, because it has been shown that the reduction in morbidity (OR, 0.41; \( P = 0.005 \)) does not occur if fluid restriction is initiated only in the postoperative setting. Vasopressors should be used intraoperatively to maintain mean arterial pressure when needed to avoid fluid overload.

- In major open procedures and for high-risk patients, when there is extensive blood loss (>7 mL/kg), the use of advanced hemodynamic monitoring to facilitate individualized fluid therapy and optimize oxygen delivery through the perioperative period is recommended.

Minimally Invasive Procedures

Minimally invasive surgical procedures have shown benefit with regard to perioperative outcomes by decreasing intraoperative blood loss, analgesic requirements, time to return of bowel function, length of hospitalization, and time to return to normal daily activities. Although most investigations of ERAS programs have been performed in the setting of open procedures, there are several studies proving that ERAS programs are also beneficial for patients undergoing laparoscopic operations. In the setting of vaginal hysterectomy there is evidence to support that an ERAS program reduces LOS by 51.6% and enables more women to be discharged within 24 hours, with no increase in patient readmission rates and higher patient satisfaction scores. Elements of particular value for an ERAS program in minimally invasive procedures include avoidance of prolonged nasogastric intubation, maintenance of normothermia, normovolemia with maintenance of adequate cardiac output (affected in minimally invasive procedures by head-down position and pneumoperitoneum), prevention of postoperative ileus, and early mobilization.

Postoperative Components

Postoperative Nausea and Vomiting Prophylaxis

PONV is very common and troubling for patients undergoing gynecologic surgical procedures. Vomiting occurs in 12% to 30% and nausea in 22% to 80% of patients, potentially leading to prolonged hospitalization and distress. Female sex, nonsmoking status, obesity, age older than 50 years, history of motion sickness, long duration of anesthesia, and use of volatile anesthetic agents, nitrous oxide, and opioids increase the risk of PONV significantly. A multimodal approach to PONV combines nonpharmacologic and pharmacologic antiemetic techniques. Nonpharmacologic options include avoiding emetogenic stimuli such as use of propofol infusions, avoiding nitrous oxide and volatile anesthetics, reducing opioid use, decreasing neostigmine dose, including carbohydrate loading as part of preoperative patient care, maintaining adequate hydration of patients, and minimizing preoperative fasting.

The recommended pharmacologic antiemetics for PONV prophylaxis in adults include the 5-hydroxytryptamine (5-HT\(_3\)) receptor antagonists (ondansetron, dolasetron, granisetron, tropisetron, ramvasonet, and palonosetron), neurokinin-1 (NK-1) receptor antagonists (aprepitant, casopitant, and rolapitant), corticosteroids (dexamethasone and methylprednisolone), butyrophenones (droperidol and haloperidol), antihistamines (dimenhydrinate and meclizine), and anticholinergics (transdermal scopolamine). Combinations of two or more classes of antiemetics may enhance their potency (e.g., aprepitant, ondansetron, midazolam, or haloperidol combined with dexamethasone). Patients undergoing gynecologic procedures should receive prophylaxis using a multimodal approach to PONV (more than two antiemetic agents).

Multimodal Analgesia

Postoperative pain management is a key point in the setting of perioperative surgical care and a central ERAS component. Several studies have shown that more than 80% of patients who undergo surgical procedures experience acute postoperative pain and that the pain intensity is moderate, severe, or extreme in 75% of them. Moreover, 80% of patients reported an adverse drug event, most of which were consistent with opioid use. Evidence suggests that less than half of patients who undergo surgical procedures report adequate postoperative pain relief. Inadequately controlled pain negatively affects quality of life, functional recovery, the risk of postsurgical complications, and the risk of persistent postsurgical pain.

With the intention of achieving adequate pain management in the postoperative period, opioids, in particular, were adopted as the cornerstone of treatment for postsurgical pain. However, there is growing concern related to their risk of generating tolerance and dependence in patients who are exposed during the postoperative period and who ultimately become long-term users. The American Society of Addiction Medicine (ASAM) reported that prescription pain relievers were four times more likely to be prescribed in 2010 than in 1999 and that the overdose death rate in 2008 was nearly four times the rate in 1999. Drug overdose is the leading cause of accidental death in the United States, and opioid addiction is driving this epidemic, with 18,893 overdose deaths related to prescription pain relievers in 2014. It is also known that four in five heroin users started misusing prescription painkillers. The safety profile and cost issues associated with standard opioid-only analgesic regimens have led to a growing trend toward multimodal analgesic approaches to the management of postsurgical pain.

Multimodal postoperative analgesic approaches are based on the use of two or more analgesic compounds with different targets of action. The potential synergism among different analgesics may allow for opioids to be used more sparingly and only as rescue analgesia, ultimately leading to less opioid consumption. Given that more favorable analgesic effects are achieved with different types of agents through their additive or synergistic effects, the combination of nonsteroidal antiinflammatory drugs (NSAIDs) and acetaminophen should be administered regularly unless contraindicated. One current regimen is as follows: pregabalin 75 mg orally twice daily (starting the evening of postoperative day 1) for 48 hours, acetaminophen 1000 mg orally every 6 hours (starting postoperative day 0), ibuprofen 800 mg orally every 8 hours (starting postoperative day 1), oxycodone 5 mg orally every 4 hours as needed, and hydromorphone 0.5 mg intravenously every 30 minutes as needed (if pain is not relieved within 30 minutes of oxycodone administration).
Intraoperative administration of local anesthetics via wound infiltration provides postsurgical analgesia while minimizing the level of systemic drug exposure. A recent approach for increasing the duration of action of local anesthetics infiltrated in the wound involves prolonged-release formulations such as liposome bupivacaine, indicated for single-dose administration into the surgical site to produce postsurgical analgesia. Liposome bupivacaine allows fast onset of analgesia owing to a bimodal release profile with an initial peak serum concentration within 1 hour after administration, followed by a later peak that occurs within 12 to 36 hours after administration. The efficacy and safety profile of single-dose administration of liposome bupivacaine at the surgical site were evaluated in several studies, which demonstrated postsurgical analgesia for up to 72 hours, extending the median time to first postsurgical use of opioid compared with bupivacaine HCl and placebo.

- The multimodal analgesia strategy should start during anesthesia induction and continue until discharge to avoid opioid requirements, thus achieving optimal pain control. Acetaminophen and NSAIDs in combination should be administered regularly to all patients unless contraindications are present.

Avoidance of Salt and Water Overload

In an uncomplicated recovery, when patients start oral fluid and food intake, postoperative IV fluids beyond 12 to 24 hours are rarely needed. When patients are not fully able to tolerate oral fluid intake, IV fluids must be administered at a total hourly volume not to exceed 1.2 mL/kg. Balanced crystalloid solutions are preferred over 0.9% normal saline owing to the cumulative risk of hyperchloremic acidosis when 0.9% normal saline is used. Flavored high-energy protein drinks, usually prescribed for use three times a day, are safe and can bridge the dietary gap in the postoperative period, thus leading back to a normal diet to ensure adequate protein and calorie intake.

One of the concerning issues regarding restrictive fluid management as generally indicated in ERAS programs is the potential increase in acute kidney injury (AKI). Researchers at MD Anderson Cancer Center evaluated 272 patients in an ERAS program and compared them with 74 patients before implementation of the ERAS program (J. D. Lasala, G. E. Mena, M.D. Iniesta, et al., unpublished data, May 2017). The incidence of acute renal compromise using the RIFLE criteria (risk, injury, failure, loss, end-stage renal disease) was 12.5% for patients in the ERAS group versus 9.5% for the pre-ERAS group (P = .5483). Patients in the ERAS group with acute renal compromise had a median LOS of 6 days (range, 2–57 days), whereas those without acute renal compromise had a median LOS of 3 days (range, 1–24) (P < .0001).

Goal-directed fluid therapy may be used as a primary component of the intraoperative guidelines, retraining from restriction of fluids only to diminish AKI. Oliguria as low as 20 cm³/h is a normal response to a surgical procedure, and the need for further IV fluid boluses should be assessed within the clinical context.

- IV fluids should be discontinued within 24 hours after an operation. Balanced crystalloid solutions are preferred to 0.9% normal saline.
- Anesthesiologists should aim to use goal-directed fluid therapy whenever possible, and it should be customized to each individual patient.

Early Oral Nutrition

In the era before implementation of ERAS programs, oral intake after major gynecologic surgical procedures was generally delayed until return of bowel function (positive bowel sounds, passage of gas or stool, and hunger) because of concerns regarding vomiting, paralytic ileus, aspiration and pneumonia, wound dehiscence, and anastomotic leakage. More recently, early feeding (oral intake of fluids or food within the first 24 hours after operation) has been studied in several trials in gynecologic oncology patients. A Cochrane review that included five RCTs with a total of 631 patients evaluated the benefits of early feeding. This review showed that recovery of bowel function was faster in patients with early feeding, with no difference in rates of nausea or vomiting, abdominal distention, and need for a postoperative nasogastric tube. Solid diet was resumed 1.5 days sooner in patients in the early feeding group (mean difference [MD], −1.47 days; 95% CI, −2.26 to −0.68 days; P = .0003). Hospital stay was shorter in the early feeding group (MD, −0.92 days; 95% CI, −1.53 to −0.31 days; P = .003).

Infectious complications were less in the early feeding group (relative risk [RR], 0.20; 95% CI, 0.05–0.73; P = .02). One study reported higher levels of satisfaction in patients who had early feeding.

- A regular diet within the first 24 hours after a gynecologic oncology surgical procedure is recommended.

Removal of Urinary Catheter

Urinary tract infection (UTI) is the most common hospital-acquired infection, accounting for 20% to 40% of cases. Up to 80% of UTIs occurring in hospitals can be attributed to the use of urethral catheters. Catheter-associated UTIs account for significant morbidity and increase health care costs by prolonging hospital stay. The best approach to reducing the risk of UTI includes decreasing the number of unnecessary catheterizations or the time period during which the catheter is used by removing it as early as possible. The primary indications for postoperative bladder drainage are to monitor urine output and prevent urinary retention. However, there is considerable variation in the duration of bladder drainage after operation for gynecologic cancers. A Cochrane review of policies for removal of short-term urinary catheters identified evidence that early catheter removal shortens length of hospital stay.

- Urinary catheters should be used for postoperative bladder drainage for a short period, preferably 24 hours postoperatively.

Early Mobilization

Early postoperative ambulation may reduce surgical complications such as atelectasis, pneumonia, venous thromboembolism, insulin resistance, and muscle atrophy. In addition, early ambulation also shortens recovery time and length of hospital stay. A number of perioperative factors, such as urinary catheter placement, IV fluid administration for more than 24 hours, and poor pain control, have been identified as barriers to ambulation. Given the emphasis of ERAS programs to diminish these elements, it is generally recognized that compliance with such elements of the ERAS program will promote early ambulation.

- Patients should be encouraged to mobilize within 24 hours of a surgical procedure.

Postoperative Glucose Control

The surgical stress response triggers a cascade of sympathetic nervous system and endocrine responses that increase cortisol secretion, which leads to a net increase in peripheral insulin resistance. Traditional perioperative interventions such as
MBP, preoperative fasting, and slow resumption of normal diet all contribute to an insulin-resistant state and have been shown to increase perioperative complications and increase length of hospital stay.\textsuperscript{[118]} Perioperative hyperglycemia (glucose levels >180–200 mg/dL) is associated with poor clinical outcomes including increased perioperative mortality, hospital LOS, intensive care unit LOS, and postoperative infection.\textsuperscript{[119]} Blood glucose targets of 180 to 200 mg/dL are recommended in an effort to prevent significant hyperglycemia while avoiding iatrogenic hypoglycemia.\textsuperscript{[120]}

- ERAS elements that reduce metabolic stress should be used to reduce insulin resistance and the development of hyperglycemia. Glucose levels above 180 to 200 mg/dL should be managed with insulin infusions and regular blood glucose monitoring to avoid the risk of hypoglycemia.

**Audit of Compliance and Outcomes**

The accomplishment of an ERAS program depends highly on multidisciplinary teamwork and patient compliance. Multidisciplinary involvement makes several aspects of the program vulnerable to failure and may explain the reported differences in the rates of adherence to the various components of ERAS.\textsuperscript{[121]}

Each member of the team should be tasked with a specific responsibility to ensure that full compliance with all elements of the ERAS program is maintained. Staff education programs before implementation of the ERAS pathway are essential for its success. Audit of compliance is of paramount importance in the success of any ERAS program. Systematic audits and feedback are essential to improve clinical results.\textsuperscript{[89]} Although much has been published about the benefits of an ERAS program, few studies have assessed compliance. It seems that even in hospitals in which an ERAS protocol has been implemented, adherence to its elements is incomplete.\textsuperscript{[122]}

Several studies have been published on compliance with ERAS programs for hepatic, pancreatic, and colorectal operations. Wong-Lun-Hing and co-workers\textsuperscript{[123]} performed a retrospective study of 165 patients to analyze compliance in hepatic surgical procedures. The authors classified compliance as “full,” “partial,” or “poor” whenever 80% or more, 50% or more, or fewer than 50% of the 22 ERAS protocol core items were met. They found compliance was partial in the preoperative (median, 2 of 3 items; range, 1–3) and perioperative phases (median, 5 of 10 items; range, 4–7). Median postoperative compliance was poor (median, 2 of 9 items; range, 0–4). In another study of 115 patients who underwent a pancreaticoduodenectomy, Braga and co-workers\textsuperscript{[124]} analyzed compliance with the preoperative and intraoperative ERAS items. They found that adherence to postoperative targets was suboptimal (mobilization, 47%; oral liquids, 55%; solid food, 53%; IV fluid withdrawal, 38%; epidural analgesia suspension, 66%). A subgroup analysis performed according to short-term outcome showed a significantly higher adherence in patients who did not experience a postoperative complication, and a progressively lower compliance was found in accordance with the severity of postoperative complications. Gustafsson and co-workers,\textsuperscript{[89]} in their study including 953 colorectal cancer patients, found an association between improved protocol adherence and improved perioperative outcomes. After an overall increase in preoperative and perioperative adherence to the ERAS protocol from 43.3% in 2002 to 70.6% in 2005 to 2007, both postoperative complications (OR, 0.73; 95% CI, 0.55–0.98) and symptoms (OR, 0.53; 95% CI, 0.40–0.70) declined significantly (restriction of IV fluid and preoperative carbohydrate drink were major independent predictors). Across periods, the proportion of adverse postoperative outcomes (30-day morbidity, symptoms, and readmissions) was significantly reduced with increasing adherence to the ERAS protocol (70%, 80%, and 90%, respectively) compared with low ERAS adherence (50%). A 27% increase in overall adherence to the ERAS protocol was associated with a 27% reduction in relative risk of any 30-day postoperative morbidity (OR, 0.73; 95% CI, 0.55–0.98). In a subsequent study, Gustafsson and co-workers\textsuperscript{[125]} reported on a follow-up analysis using the same cohort of patients and showed that increased adherence (≥70%) to the ERAS interventions was associated with significantly improved 5-year survival compared with patients with less than 70% adherence.

In summary, it appears that increasing compliance with ERAS protocol items has a direct impact on perioperative outcomes, and it also seems to affect the 5-year survival rate in patients with colorectal cancer. Thus far, no data have been published on ERAS compliance in gynecologic oncology. There is also a gap of knowledge regarding which ERAS elements have the greatest implications for perioperative outcomes, and further studies are needed to answer this important question.

**Summary**

The implementation of an ERAS program results in significant overall improvements in the perioperative outcomes of patients undergoing gynecologic surgical procedures. It is exceedingly important to create a multidisciplinary team that prioritizes the principles of a high degree of compliance with all elements of the ERAS program. Once a program has been implemented, it is also crucial to ensure that appropriate measures are taken to capture outcome data on clinical and quality-of-life parameters in order to strategize for future improvement and modification of such programs. It is imperative that gynecologic surgeons and respective departments consider the implementation of ERAS programs; there is ample evidence to support the principles of faster recovery in all aspects of patient care. It is anticipated that all surgical specialties in the very near future will consider ERAS programs a part of the standard of care.

**References**


Chapter 3  Enhanced Recovery After Surgery in Gynecologic Oncology Surgery


Chapter 3 Enhanced Recovery After Surgery in Gynecologic Oncology Surgery


In the past 100 years, the surgical approach to vulvar cancer has evolved from one of gynecologic oncology's most morbid procedures to one of its least. The original approach included the radical en bloc resection of the vulva, groins, and iliac lymph nodes (Fig. 4.1A). Although this procedure greatly improved survival compared with earlier procedures, postoperative morbidity was exceedingly high as patients often experienced wound separation with prolonged healing, lymphedema, and long hospitalizations. The rationale for this radical approach was based on concern that tumor could potentially implant in the "skin bridge" between the primary lesion on the vulva and the lymph nodes in the inguinofemoral triangle. However, although in-transit tumor emboli were occasionally observed pathologically in the lymphatic channels of these en bloc resection specimens, true tumor implants were never encountered. Although recurrences in the skin bridge may occur, the short- and long-term morbidity of en bloc resection was felt to outweigh the risks of skin bridge recurrence, so surgeons moved to performing the primary resection and groin node evaluation(s) through separate incisions (Fig. 4.1B). Consequently the morbidity of wound separation and prolonged hospital stay significantly decreased, and oncologic outcomes were not compromised. Although separate incisions reduced wound complications, lymphedema remained a major postoperative long-term morbid condition, with 64% of women with vulvar cancer experiencing either grade 2 or grade 3 lymphedema after complete inguinofemoral lymphadenectomy. In an effort to reduce this morbidity, techniques for lymphatic mapping and sentinel nodes were pioneered and were proved to be valid for treating women with early-stage vulcan cancer (Fig. 4.1C). The adoption of lymphatic mapping and sentinel node biopsy for the treatment of vulvar cancer reduced the rate of lymphedema to less than 2%, again without compromising oncologic outcomes.

Among the gynecologic malignancies, vulvar cancer is the fourth most common, behind uterine, ovarian, and cervical cancers and just ahead of vaginal cancer. Approximately 5% of all gynecologic malignancies will arise from the vulva. A woman's lifetime risk of developing vulvar cancer is 0.3%; 2.5 new vulvar cancers occur per 100,000 women per year in the United States. The overall 5-year survival rate for all patients with vulvar cancer is 72%. When disease is limited to the vulva, the 5-year survival rate is 86.4% compared with 56.9% when disease has spread to regional lymph nodes and 17.4% when distant disease is present (Table 4.1). Vulvar cancer remains a surgically staged disease, with International Federation of Gynecology and Obstetrics (FIGO) staging correlating well with the localized (stages I and II), regional (stage III), and distant (stage IV) disease states described earlier (Table 4.2).

Most (95%) vulvar cancers will have squamous histologic characteristics, with melanoma being the next most common subtype. Other subtypes of vulvar cancer that are seen infrequently include Bartholin gland carcinoma, adenocarcinoma arising in patients with Paget disease, basal cell carcinoma, verrucous carcinoma, and vulvar sarcomas. Finally, there are the exceedingly rare vulvar cancers found in limited case reports, which include endodermal sinus tumors, Merkel cell carcinomas, dermatofibrosarcoma protuberans, and malignant schwannomas (Table 4.3).

There appear to be two independent pathways for the development of invasive squamous cell carcinoma of the vulva. The first tends to be associated with high-risk human papillomavirus (HPV) subtypes and accounts for 60% of vulvar cancers. The majority of the HPV-associated vulvar cancers harbor HPV-16 (80%–90%), with the remainder having either HPV-18 or HPV-33 subtype present. The HPV-associated vulvar cancers occur more frequently in younger women, many of whom report a prior history of genital warts or vulvar and/or cervical dysplasia. Immunosuppressed women are also more likely to follow this pathway to the development of vulvar cancer.

The other pathway, which affects older women, appears to be HPV independent. These cancers appear to be related to chronic inflammation. Many of these women will have had previous diagnoses of lichen sclerosis or squamous cell hyperplasia, and although the risk of development of invasive vulvar cancer in women with these lesions in 4.5%, neither lichen sclerosis nor squamous cell hyperplasia itself is considered a premalignant lesion. Women with HPV-negative tumors tend to have a worse prognosis compared with those with HPV-positive squamous cell carcinomas of the vulva.
TABLE 4.1 Incidence and Survival for Vulvar Cancer Patients by Disease Extent

<table>
<thead>
<tr>
<th>Disease Extent</th>
<th>Percent of Cases</th>
<th>5-Year Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>Localized (confined to vulva)</td>
<td>59%</td>
<td>86.4%</td>
</tr>
<tr>
<td>Regional (spread to lymph nodes)</td>
<td>30%</td>
<td>56.9%</td>
</tr>
<tr>
<td>Distant (spread beyond lymph nodes)</td>
<td>6%</td>
<td>17.4%</td>
</tr>
<tr>
<td>Unknown/Unstaged</td>
<td>5%</td>
<td>56.2%</td>
</tr>
</tbody>
</table>

FIG. 4.1 Evolution of the surgical management of vulvar cancer from (A) en bloc resection of vulva, groins, and iliac lymph nodes to (B) “triple” incision resection of primary tumor and inguinofemoral lymph nodes to (C) wide radical excision and sentinel lymph node biopsies.

TABLE 4.2 FIGO Staging for Carcinoma of the Vulva

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage I</td>
<td>Tumor confined to the vulva</td>
</tr>
<tr>
<td>IA</td>
<td>Lesions ≤2 cm in size, confined to the vulva or perineum and with stromal invasion ≤1.0 mm, no nodal spread</td>
</tr>
<tr>
<td>IB</td>
<td>Lesions &gt;2 cm in size or with stromal invasion &gt;1.0 mm, confined to the vulva or perineum, no nodal spread</td>
</tr>
<tr>
<td>Stage II</td>
<td>Tumor of any size with extension to adjacent perineal structures (lower third urethra, lower third vagina, anus), no nodal spread</td>
</tr>
<tr>
<td>Stage III</td>
<td>Tumor of any size with or without extension to adjacent perineal structures (lower third urethra, lower third vagina, anus) with positive inguinofemoral lymph nodes</td>
</tr>
<tr>
<td>IIIA</td>
<td>(i) With 1 lymph node metastasis (≥5 mm) or (ii) 1 or 2 lymph node metastasis(es) (&lt;5 mm)</td>
</tr>
<tr>
<td>IIIB</td>
<td>(i) With 2 or more lymph node metastases (≥5 mm) or (ii) 3 or more lymph node metastases (&lt;5 mm)</td>
</tr>
<tr>
<td>IIIC</td>
<td>With positive nodes with extracapsular spread</td>
</tr>
<tr>
<td>Stage IV</td>
<td>Tumor invades other regional (2/3 upper urethra, 2/3 upper vaginal), or distant structures</td>
</tr>
<tr>
<td>IVA</td>
<td>Tumor invades any of the following: (i) Upper urethral and/or vaginal mucosa, bladder mucosa, rectal mucosa, or fixed to pelvic bone or (ii) Fixed or ulcerated inguinofemoral lymph nodes</td>
</tr>
<tr>
<td>IVB</td>
<td>Any distant metastasis including to pelvic lymph nodes</td>
</tr>
</tbody>
</table>

FIGO, International Federation of Gynecology and Obstetrics.

TABLE 4.3 Differential Diagnosis of Vulvar Lesions

<table>
<thead>
<tr>
<th>Benign Lesions (Common)</th>
<th>Premalignant Lesions</th>
<th>Invasive Carcinomas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lichen sclerosis</td>
<td>Vulvar intraepithelial neoplasia</td>
<td></td>
</tr>
<tr>
<td>Condyloma</td>
<td>Melanoma in situ</td>
<td></td>
</tr>
<tr>
<td>Molluscum contagiosum</td>
<td>Squamous carcinoma</td>
<td></td>
</tr>
<tr>
<td>Paget disease</td>
<td>Melanoma</td>
<td></td>
</tr>
<tr>
<td>Squamous cell hyperplasia</td>
<td>Bartholin gland cancer</td>
<td></td>
</tr>
<tr>
<td>Lichen planus</td>
<td>Adenocarcinoma arising in Paget disease</td>
<td></td>
</tr>
<tr>
<td>Lichen simplex chronicus</td>
<td>Basal cell carcinoma</td>
<td></td>
</tr>
<tr>
<td>Lentigo simplex</td>
<td>Verrucous carcinoma</td>
<td></td>
</tr>
<tr>
<td>Vulvar melanosis</td>
<td>Vulvar sarcomas</td>
<td></td>
</tr>
<tr>
<td>Benign nevi</td>
<td>Endodermal sinus tumors</td>
<td></td>
</tr>
<tr>
<td>Hidroadenoma</td>
<td>Merkel cell carcinomas</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dermatofibrosarcoma protuberans</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Malignant schwannomas</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aggressive angiomyxoma</td>
<td></td>
</tr>
</tbody>
</table>
**Presentation, Diagnosis, and Workup**

**Presentation**

Many patients with vulvar cancer will be asymptomatic, whereas others may complain of pruritus, particularly older patients with HPV-negative disease, because lichen sclerosus is often present in addition to invasive cancer. The classic presentation is a vulvar abnormality such as a plaque or mass. These lesions may be ulcerated, leukoplakic, or warty. Melanoma lesions may be darkly pigmented, but occasionally they can be amelanotic.

**Diagnosis**

The differential diagnosis of vulvar lesions ranges from benign lesions to invasive cancer (see Table 4.3). Vulvar biopsy must be performed on any suspicious lesions to confirm pathologic findings and to manage the condition appropriately. Health care professionals should have a very low threshold for performing biopsy on abnormal-appearing lesions on the vulva. In fact, one might consider the mantra “When in doubt, biopsy!” Because vulvar carcinoma can be multifocal in up to 5% of patients, multiple biopsies of abnormal-appearing areas must be undertaken.

A vulvar punch biopsy is the most commonly used procedure to arrive at a diagnosis. This procedure can be done in the clinic or office with local anesthesia. One must be sure to get an adequate sample that includes both dermis and underlying connective tissue to determine depth of invasion if invasive cancer is present.

After verbal or written consent has been obtained from the patient, the area around the lesion should be prepared with iodine or chlorhexidine. Once this is done, 2 to 3 mL of 1% to 2% lidocaine with or without epinephrine is injected around the lesion to form a wheal under the lesion. The biopsy specimen should be taken from the edge of the lesion as opposed to the center. It is ill advised to perform biopsy of the clitoris in the clinic because biopsy of this highly sensitive area will be poorly tolerated and should be performed with the patient under general anesthesia.

Use of a Keyes biopsy punch (Fig. 4.2) is recommended, although a scalpel or scissors can be used. The Keyes biopsy punch is more likely to achieve adequate depth in the biopsy area, which is important if the lesion is invasive carcinoma. Although a punch biopsy ranges in size from 2 to 10 mm, generally 3 to 5 mm in size is adequate for a pathologic diagnosis of most lesions without causing too much discomfort or bleeding.

To perform the procedure, one presses the biopsy punch perpendicularly against the skin, holds it taut with the nondominant hand, and rotates with firm pressure. Ideally the rotation will be in one direction only (clockwise or counterclockwise) to avoid shredding the sample, but on occasion back-and-forth rotation is necessary. Once the instrument has reached adequate depth, the specimen is grasped with forceps and elevated, allowing for scissors or a scalpel to be used to transect the specimen at its base for pathologic processing.

Hemostasis is usually easily achieved with pressure or silver nitrate sticks. Monsel solution can also be used if bleeding is a bit brisker. Occasionally a suture will be needed to control bleeding, although this is rare.

**Preoperative Workup**

A careful physical examination with particular attention to the inguinal-femoral groin nodes and local extent of disease should be performed. Once a pathologic diagnosis of invasive carcinoma with greater than 1 mm in depth of invasion has been made, preoperative imaging should be performed to rule out regional and distant disease. For squamous cell carcinomas, positron emission tomography–computed tomography (PET-CT) is favored because its sensitivity in detecting metastatic disease to the groins is greater than 90% (Fig. 4.3). However, a CT scan or magnetic resonance imaging (MRI) is also acceptable because these modalities may have equivalent sensitivities and specificities to PET scan in assessing metastatic disease. Ultrasonography of the groins may also be considered for evaluation of metastatic disease to inguino-femoral lymph nodes. If there is concern for rectal or urethral invasion, MRI of the pelvis may be performed to assess tumor involvement of these structures. For women with adenocarcinoma arising in Paget disease, a complete workup for synchronous tumors must be undertaken because up to 30% of patients may have a second, noncontiguous primary carcinoma. The most frequently associated malignancies include breast, rectal, bladder or urethral, cervical, and basal cell carcinomas.

**Preoperative Considerations**

**Anatomy**

Primary vulvar carcinoma includes lesions of the labia majora, labia minora, clitoris, or perineum. For ambiguous lesions involving the vulvar structures and the anus or urethra, it is sometimes difficult to assign a primary site, and these lesions should be approached in a multidisciplinary manner. By convention, masses that include both the vulva and the vagina are considered primary vulvar carcinomas.

The vulva and lower third of the vagina have consistent lymphatic drainage to the inguino-femoral lymph nodes through a rich network of lymphatic channels (Fig. 4.4). The anatomic
FIG. 4.3 Positron emission tomography–computed tomography (PET-CT) scan showing bilateral fluorodeoxyglucose (FDG)-avid groin nodes in both axial (A) and coronal (B) views.

FIG. 4.4 Lymphatic drainage of the vulva.
In our surgical oncology practice, the boundaries of the inguinofemoral dissection (the femoral triangle) for vulvar cancer patients include the inguinal ligament superiorly, the adductor longus muscle medially, and the sartorius muscle crossing laterally from the thigh medially to just above the knee (Fig. 4.5). Although some texts describe direct lymphatic drainage from the clitoris to the pelvic lymph nodes (iliac or obturator), metastatic disease to the pelvic nodes in the absence of positive groin nodes is exceedingly rare. Routine dissection of pelvic nodes is not recommended as part of the primary operation for vulvar cancer (including clitoral lesions) unless bulky disease is noted at preoperative imaging.

The terms superficial and deep dissections have different meanings in surgical oncology. For example, in the treatment of a lower limb melanoma, superficial dissection refers to the groin nodes, whereas deep dissection refers to pelvic nodes. In gynecologic oncology, both terms refer to the inguinoofemoral lymphadenectomy alone. Superficial dissection involves those nodes found between the Camper fascia and the fascia lata. The deep nodes are those along the femoral vessels, beneath the fascia lata and inguinal ligament. Cloquet’s node, just inside the fossa ovalis, is thought to be the transition from the superficial nodal bundle to the deep. Although there does not seem to be a risk of direct drainage to the pelvic nodes in the absence of positive groin nodes, there may be metastases from the vulva to the deep groin nodes in the absence of spread to the superficial nodes. It is therefore important to resect both superficial and deep nodes when performing a complete inguinoofemoral lymphadenectomy because groin recurrences of 7% have been reported when only a superficial node dissection is performed.14

**Primary Surgical Treatment Versus Primary Radiation**

In general, women with clinical T1 or T2 lesions with clinically negative lymph nodes are excellent candidates for primary surgical treatment with intent to cure (Table 4.4). In triaging patients to surgical treatment or chemoradiation, it is recommended that the treatment algorithm outlined in Fig. 4.6 be followed. Although this algorithm can serve as a general model for treating women with vulvar cancer, deviations for larger T2 tumors may occur based on ability to obtain adequate surgical margins (see later) and to preserve involved organ function (i.e., urinary or bowel). In these scenarios, individualized treatment planning must occur.

**Surgical Planning for Resection of Primary Tumor**

As mentioned, the treatment of the primary lesion has evolved from en bloc resection of vulva, the groin nodes, and the skin bridge between them to separate incisions for primary lesion and inguinofemoral dissection. Although metastatic implants in the skin bridge were never seen in en bloc resections, in-transit tumor emboli were frequently noted. These tumor emboli within lymphatic channels may get “trapped” in the skin bridge during primary resection and groin dissection through separate incisions, and disease recurrence within the skin bridge has been reported in 0% to 6% of patients.15-17 In our clinical experience, skin bridge recurrence is exceedingly rare, and the risks and morbidity of the en bloc resection far outweigh the low probability of a skin bridge recurrence.

Achieving an adequate surgical margin is of the utmost importance in resection of the primary lesion on the vulva. When a pathologic margin of 1 cm or greater is achieved, local recurrence on the vulva approaches 0% with surgical treatment alone.18 In contrast, when the pathologic margin of the primary specimen is less than 8 mm, almost half of these patients will experience recurrence of disease if adjuvant therapy is not administered. To achieve a pathologic margin of 1 cm, the surgeon should resect more than 2 cm circumferentially from the edges of the tumor observed grossly. This will allow for microscopic extension of disease as well as shrinkage of the resected specimen on fixation for pathologic sectioning.

**Surgical Planning for Inguinofemoral Lymph Nodes**

Lymph node status remains the most important prognostic factor for women with vulvar cancer. For women with negative lymph nodes, recurrence rates in the groin are less than 2%, compared with as high as 40% for those with metastatic disease in the inguinofemoral lymph nodes.19 Depth of invasion remains an important predictor of nodal spread in women with vulvar cancer. For lesions invading less than 1 mm, the risk of nodal disease approaches 0%, as opposed to 8% for lesions invading 1 to 3 mm, about 33% for lesions invading 3 to 5 mm, and 48% for lesions invading more than 5 mm (Table 4.5).20 For tumors 2 cm or smaller, the risk of metastatic disease to regional lymph nodes is 19% compared with 42% for lesions larger than 2 cm.20 For these reasons, lymph node assessment either by
complete inguino-femoral lymphadenectomy or sentinel lymph node biopsy must be undertaken in women with clinical T1b or T2 lesions (see Fig. 4.6).

The decision to perform unilateral or bilateral nodal assessments has traditionally been based on the anatomic location of the primary tumor in relationship to the midline. For lesions whose medial edge is more than 2 cm from the midline, unilateral nodal assessment of the ipsilateral inguino-femoral groin nodes is adequate. For lesions that cross the midline, bilateral nodal assessments are standard of care. Historically, surgeons have performed bilateral nodal assessments for lesions with a medial border less than 2 cm from the midline but not crossing the midline. About 28% of lesions will fit this category of “lateral ambiguous” (with 45% crossing the midline and 27% more lateral than 2 cm from the midline). When preoperative lymphoscintigraphy is performed in these patients, 42% of them will have only unilateral drainage to the ipsilateral inguino-femoral nodes. In patients with a lateral ambiguous lesion and preoperative lymphatic mapping showing only ipsilateral drainage, none has positive metastatic disease in the contralateral nodal basins. This would suggest that contralateral lymph node assessment can be eliminated in this specific group of patients. In patients with lateral ambiguous lesions that have bilateral drainage on preoperative mapping, bilateral nodal assessments must be performed.

When a complete inguino-femoral lymphadenectomy is performed, preservation of the saphenous vein should be attempted in all patients to reduce lymphedema. In a prospective, randomized trial comparing saphenous vein sparing with ligation in women who have vulvar cancer undergoing groin node dissections, sparing the saphenous vein significantly lowered the likelihood of lower extremity lymphedema, chronic pain, and chronic cellulitis without increasing recurrences. Multiple retrospective studies support the findings of decreased morbidity without compromising oncologic outcomes when the saphenous vein is spared during

### TABLE 4.4 TNM Classification and FIGO Staging for Vulvar Cancer

<table>
<thead>
<tr>
<th>TNM Category</th>
<th>FIGO Stage</th>
<th>Definition</th>
<th>Surgical Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Tumor (T)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TX</td>
<td>Primary tumor cannot be assessed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T0</td>
<td>No evidence of primary tumor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tis</td>
<td>Carcinoma in situ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1a</td>
<td>IA</td>
<td>Lesions 2 cm or smaller, confined to the vulva or perineum, and wide stromal invasion 1 mm or less</td>
<td>WLE, no LNA</td>
</tr>
<tr>
<td>T1b</td>
<td>IB</td>
<td>Lesions larger than 2 cm or of any size with stromal invasion more than 1 mm, confined to the vulva or perineum</td>
<td>WLE, LNA ipsilateral</td>
</tr>
<tr>
<td>T2</td>
<td>II</td>
<td>Tumor of any size with extension to adjacent perineal structures (lower or distal third urethra, lower or distal third vagina, anal involvement)</td>
<td>Modify radical vulvectomy (hemivulvectomy, anterior or posterior vulvectomy), bilateral LNA Neoadjuvant chemoradiation and selected surgical procedure, no LNA</td>
</tr>
<tr>
<td>T3</td>
<td>IVA</td>
<td>Tumor of any size with extension to any of the following: upper or proximal 2/3 urethra, upper or proximal 2/3 vagina, bladder mucosa, or rectal mucosa or fixed to pelvic bone</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Regional Lymph Nodes (N)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>NX</td>
<td>Regional lymph nodes cannot be assessed</td>
<td></td>
</tr>
<tr>
<td>N0</td>
<td>No regional lymph node metastasis</td>
<td></td>
</tr>
<tr>
<td>N1</td>
<td>One or two regional lymph nodes with the following features</td>
<td></td>
</tr>
<tr>
<td>N1a</td>
<td>IIIA</td>
<td>One or two node metastases, each 5 mm or smaller</td>
</tr>
<tr>
<td>N1b</td>
<td>IIIA</td>
<td>One lymph node metastasis 5 mm or larger</td>
</tr>
<tr>
<td>N2</td>
<td>Regional lymph node metastasis with the following features</td>
<td></td>
</tr>
<tr>
<td>N2a</td>
<td>IIIB</td>
<td>Three or more lymph node metastases each less than 5 mm</td>
</tr>
<tr>
<td>N2b</td>
<td>IIIB</td>
<td>Two or more lymph node metastases 5 mm or greater</td>
</tr>
<tr>
<td>N2c</td>
<td>IIIC</td>
<td>Lymph node metastasis with extracapsular spread</td>
</tr>
<tr>
<td>N3</td>
<td>IVA</td>
<td>Fixed or ulcerated regional lymph node metastasis</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Distant Metastasis (M)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>M0</td>
<td>No distant metastasis</td>
<td></td>
</tr>
<tr>
<td>M1</td>
<td>Distant metastasis (including pelvic lymph node metastasis)</td>
<td></td>
</tr>
</tbody>
</table>

FIGO, International Federation of Gynecology and Obstetrics; LNA, lymph node assessment; WLE, wide local excision.
inguinofemoral lymphadenectomy. Of course, the greatest effect in reducing postoperative lower limb morbidity in women with vulvar cancer has been achieved by the introduction and validation of the sentinel node concept.

### Sentinel Nodes in Vulvar Cancer

Lymphatic mapping and sentinel lymph node biopsy can now be considered a standard-of-care option for women with T1 or T2 vulvar cancers. In addition to reducing the risk of lymphedema to below 2%, use of sentinel lymph node biopsy also decreases risk of lymphocele formation, vascular injury, and wound separation. Also important, when combined with ultrastaging and immunohistochemistry, the detection and removal of sentinel nodes leads to increased identification of small-volume disease in regional lymph nodes, providing more precise information to guide adjuvant therapy.

Two studies established the validity and oncologic safety of sentinel lymph node biopsy alone in women with cervical cancer. GOG-173 (Gynecologic Oncology Group 173) was a true validation study in which lymphatic mapping and sentinel lymph node biopsy followed by complete inguinofemoral lymphadenectomy were performed prospectively in women with squamous cell vulvar cancers smaller than 6 cm. The study enrolled 515 patients to reach a final sample size of 132 women with metastatic disease to the regional lymph nodes. Overall, at least one sentinel node was identified in 92.5% of patients, with an average of 1.5 nodes per groin found. The sensitivity of the procedure was 91.7%, with a negative predictive value of 96.3%. For tumors smaller than 2 cm, the negative predictive value was 98%. The sentinel node procedure is less accurate as tumors increase in size, and extreme caution must be used for lesions larger than 4 cm. In fact, we do not recommend using the technique for tumors larger than 4 cm and instead perform complete inguinofemoral lymphadenectomy.

Unlike the validation study of GOG-173, the GROINSS-V study (Groningen International Study on Sentinel Nodes in Vulvar Cancer) was an observational study of oncologic outcomes among women who underwent a sentinel lymph node biopsy only for assessment of nodal metastases to regional lymph nodes. In this study, women with squamous cell carcinoma of the vulva with tumors smaller than 4 cm underwent lymphatic mapping and sentinel node biopsy alone. Patients who had at least one sentinel node identified and no evidence of metastatic disease in any sentinel node removed were then followed for 2 years for recurrence. The recurrence rate in this group was 3%. When patients were limited to those with unifocal disease and negative sentinel nodes, the recurrence rate decreased to only 2.3%.

It is recommended that preoperative lymphoscintigraphy or single-photon emission computed tomography–computed tomography (SPECT-CT) be performed before every surgical procedure of vulvar cancer in which use of lymphatic mapping and sentinel lymph node biopsy alone is planned. Lymphoscintigram is two-dimensional planar imaging of the lymph node basins that are detected by means of peritumoral injection of

---

**TABLE 4.5** Risk of Groin Node Metastases by Depth of Invasion of Primary Lesion

<table>
<thead>
<tr>
<th>Depth of Invasion</th>
<th>Patients With Positive Groin Nodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1 mm</td>
<td>0%</td>
</tr>
<tr>
<td>1–3 mm</td>
<td>8%</td>
</tr>
<tr>
<td>3–5 mm</td>
<td>33%</td>
</tr>
<tr>
<td>&gt;5 mm</td>
<td>48%</td>
</tr>
</tbody>
</table>

---

**FIG. 4.6** Treatment algorithm for squamous cell carcinoma of the vulva.
technetium-99 (Fig. 4.7). SPECT-CT fuses the lymphoscintigram with a CT scan to create a three-dimensional view of the sentinel nodes (Fig. 4.8). Both of these preoperative imaging modalities allow for surgical planning as well as recognition of anatomically aberrant nodal basins. Lymphoscintigraphy and SPECT-CT also provide information as to whether unilateral or bilateral lymph node biopsies are needed in the lateral ambiguous lesions as described earlier.

There are two important considerations when intraoperative decisions are made in association with preoperative lymphoscintigram or SPECT-CT findings. First, the number of sentinel nodes detected and identified on preoperative imaging must correlate with intraoperative findings. If multiple sentinel nodes are identified on preoperative imaging, the same number of nodes must be identified intraoperatively. Second, if no sentinel nodes are identified in a draining basin(s) intraoperatively, then a complete inguinofemoral lymphadenectomy must be performed in that basin regardless of what was seen on preoperative imaging.

The sentinel nodes are almost always detected in the medial portion of the groin. In one study, 49% were located in the superficial compartment, medial to the saphenous vein. Another 35% were found in the superficial compartment in the vicinity of the saphenous vein, and the remaining 16% were in the deep compartment. No sentinel nodes were detected in the outer third of the superficial compartment, lateral to the saphenous vein.²⁵

**FIG. 4.7** Two-dimensional lymphoscintigraphy of pelvis.

---

### Surgical Procedures

#### Wide Local Excision

Wide local excision is typically used for treatment of vulvar dysplasias. In order for adequate pathologic margins to be obtained, a 5- to 10-mm margin is drawn circumferentially from the gross edge of the lesion by using a marking pen and a ruler in an elliptical design. The skin incision is made along the marked border by using a knife or monopolar electrocautery. The goal of the excision, sometimes called a “skinning vulvectomy,” is to remove the lesion with only 1 to 2 mm of the underlying subcutaneous tissue, so the skin incision does not need to be deep. This procedure aims to preserve the subcutaneous and deep tissue of the vulva.

Once the incision has been made circumferentially, Allis clamps or surgical forceps are used to grasp the edge of the excision, and with gentle traction the underlying tissue is undermined and dissected with use of either the knife or monopolar electrocautery. Once the specimen has been excised, a suture is typically placed at the 12-o’clock position to orient the specimen for the pathologist.

The skin edges can be reaproximated using 2-0 delayed absorbable suture either in interrupted stitches or in a running subcuticular stitch. If the excision was deeper than 2 to 3 mm, interrupted or running 3-0 delayed absorbable sutures may be used to close the deep layer in an effort to obliterate the dead space and bring the skin edges closer together for less tension on the skin layer.
Wide Radical Excision

Wide radical excision is used for treatment of invasive carcinomas (>1 mm depth of invasion). In order to obtain adequate pathologic margins of more than 8 mm (see earlier), a 2-cm gross margin both around and deep to the lesion is obtained. With a marking pen and ruler, an elliptical 2-cm margin is drawn circumferentially from the gross edge of the lesion (Fig. 4.9).

If a inguinofemoral lymphadenectomy or sentinel lymph node biopsy is to be performed, the groin procedure(s) are typically performed before the vulvar wide radical excision. The skin incision is made along the marked border by using a knife or monopolar electrocautery. The incision is carried deep to the fascia. As the skin excision is extended to the deep margin, care must be taken to remain perpendicular to the skin incision so as not to tunnel under the primary lesion and “short” the deep margin. Once the lateral and deep margins have been established, monopolar electrocautery is used to undermine and remove the specimen. The resection bed should be irrigated copiously, and good hemostasis should be obtained. Hemostasis of small perforating vessels encountered may be achieved with monopolar electrocautery or with 3-0 sutures. Large venous sinuses may be encountered near the clitoris and urethra and just under the pubis symphysis. Care should be taken in these areas to anticipate heavier bleeding, and the classic “clamp, cut, and tie” techniques should be employed as opposed to just coming through the tissue with monopolar electrocautery alone. Once the specimen has been excised, a suture is typically placed at the 12-o’clock position to orient the specimen for the pathologist.

Most wide radical resections can be reconstructed primarily, although some larger resections may require flaps or plastic surgery (see Chapter 20). The key to primary reconstruction is to obtain a tension-free reapproximation to reduce the likelihood of wound separation and other surgical morbidity. The deep spaces are closed in layers by using interrupted or running 3-0 delayed absorbable sutures. The skin edges can then be reapproximated with 2-0 delayed absorbable suture, either in interrupted stitches or in a running subcuticular suture (Fig. 4.10).

Complete Inguinofemoral Lymphadenectomy

With the patient supine or in low lithotomy position with legs flexed at the knees but not at the hips, an 8- to 10-mm skin incision is made over the Poupart ligament starting 1 to 2 cm lateral to the mons pubis and extending laterally. The incision should be 2 cm above and parallel to the inguinal ligament and groin crease. The incision is carried down to the Scarpa fascia. The upper and lower flaps are developed by undermining the skin to develop the space over the femoral triangle (see Fig. 4.5). In the development of the flaps, care must be taken to leave more than 3 mm of subcutaneous tissue on the underside of the skin to prevent devascularization and necrosis of the overlying skin. The mobilized upper and lower skin flaps can be retracted with either skin clips or a self-retaining surgical retractor (Gilkey or Harvey Jackson).

The Scarpa fascia is then incised, and the dissection is carried down to the inguinal ligament and external oblique fascia, which serve as the cephalad border of the dissection. The superficial epigastric and other perforating vessels will be encountered here, and care must be taken to ligate them before cutting through them. The superior fat pad containing the lymph nodes is dissected off the external oblique fascia.

With gentle traction on the superior portion of the fat pad just dissected off the external oblique fascia, the dissection continues inferiorly along the fascia with sharp and blunt dissection as well as with monopolar electrocautery within the borders of the femoral triangle. The dissection continues superficial to the fascia lata so the femoral vessels are not exposed. However, as the dissection moves down the fascia lata, the saphenous vein will be encountered as it perforates through, and all efforts should be made to spare this structure. The dissection continues along the fascia lata laterally to the sartorius muscle and
medially to the adductor longus, and as the fat pad is elevated out of the femoral triangle, the lateral portion of these muscles should be visualized.

Once the fossa ovalis is visualized and the cribriform fascia is encountered, an incision is made to expose the femoral vessels to remove Cloquet’s and other deep nodes that are at risk for metastatic disease. Exposure of the femoral nerve lateral to the femoral artery is not necessary during this dissection.

The dissection bed is copiously irrigated and made hemostatic. A closed suction drain (typically a Jackson-Pratt) is placed in the space, and the Scarpa fascia is reapproximated by using 3-0 delayed absorbable suture in interrupted or running stitches. The skin is reapproximated with 4-0 delayed absorbable suture or staples.

**Lymphatic Mapping and Sentinel Lymph Node Biopsy**

**Mapping Substances**

There are two substances approved by the U.S. Food and Drug Administration (FDA) for lymphatic mapping and sentinel lymph node identification in solid tumors. The first are patent blue dyes (isosulfan blue, methylene blue, and patent blue V). These dyes are taken up quickly and deposited in sentinel nodes typically in 5 to 15 minutes and may remain in the node for only 60 minutes before dissipating. Therefore dissection of the groin and identification of the sentinel node must occur.
10 to 15 minutes after injection and must be completed within 1 hour to allow enough time for the dye to reach the sentinel node but not so much time that the sentinel node is missed because the dye has moved through or dissipated. Blue dyes are considered safe, with only 1% to 2% of patients experiencing side effects. The most concerning complication—allergic reaction—is exceedingly rare, although cardiovascular collapse and pulmonary edema have been reported. Typically, allergic reaction occurs within 10 to 30 minutes after injection. Treatment of allergic reaction is supportive. Some choose to premedicate patients receiving blue dye with Benadryl and steroid. Pseudoanaphylaxis may develop, with loss of oxygen saturation and gray skin coloring without features of cardiovascular collapse. This may occur because blue dyes interfere with noninvasive pulse oximetry saturation algorithms or because they produce a known side effect of self-limiting skin color changes (typically blue or gray hues).

The second commonly used mapping substance is the gamma-emitting radioactive colloid technetium-99. Mapping substances need to be small enough to enter the lymphatic vessels for transport (<500 nm) but large enough so as not to penetrate the capillaries and disperse before reaching the sentinel node (>5 nm). The most commonly used radiopharmaceutical in the United States is filtered technetium-99–sulfur colloid. This substance is approximately 15 to 50 nm in size (unfiltered, 100–400 nm), disperses uniformly, and has a short half-life (approximately 14 hours). Unlike blue dye, which gets to the node quickly (in less than 15 minutes) but also dissipates quickly (in less than 60 minutes), technetium-99–sulfur colloid can take longer (30–40 minutes) to reach the sentinel node but will also remain in the sentinel node for much longer than blue dyes (up to 20–24 hours), although most believe that the optimal time from injection to localization (by lymphoscintigraphy and SPECT-CT or intraoperatively with a handheld gamma counter) is 1 to 6 hours. If preoperative imaging and intraoperative localization are to be used, it is recommended that either separate injections be performed more than 24 hours apart for the two procedures or injection of radiocolloid be followed by imaging and operation in the 1- to 6-hour time frame.

More recently, indocyanine green (ICG) has been used for lymphatic mapping at multiple solid tumor sites. ICG is a water-soluble tricarbocyanine dye that has a peak spectral absorption of 800 to 810 nm. With use of near infrared imaging (laser excitation at 806 nm), the dye is easily visualized in real time, producing excellent delineation of lymphatic channels and sentinel nodes. The technique requires special equipment (near infrared imaging cameras) that is not currently available at most centers. Furthermore, the compound is not yet FDA approved for lymphatic mapping but only for intravenous injection.

**Surgical Technique**

A total of 4 mL of blue dye (in 1-mL aliquots) and 1 to 2.5 mCi of technetium-99 in 2 to 4 mL of volume (divided into four equal aliquots) may be used. Mapping substances are injected intradermally in four locations circumferentially around the tumor. Typically, injections are made at the 2-o’clock, 5-o’clock, 8-o’clock, and 11-o’clock positions. Mapping substances should not be injected intratumorally but rather into normal epithelium just lateral to the gross edge of the tumor (Fig. 4.11). Intradermal injection is important to access the superficial dermal lymphatics that drain to the groin. Deeper injection may access the lymphatic channels along the major vessels mapping into the pelvis and not representing the true lymphatic drainage of the primary lesion. For adequate time to be allowed for mapping substances to reach sentinel nodes (see earlier), the technetium-99 can be injected just after induction of anesthesia and before the patient is prepared and draped; then the blue dye is injected once the surgical team is ready to start the procedure.

With a combination of preoperative imaging and intraoperative handheld gamma probe, a small incision is made over the area with the highest radioactive activity. The Scarpa fascia is incised, followed by careful dissection through the underlying tissue in an attempt to identify lymphatic channels (Fig. 4.12). Following the channel, and with the intermittent use
of the gamma probe, the sentinel node is identified and removed (Fig. 4.13). Radioactivity should be confirmed ex vivo with the gamma probe (Fig. 4.14). The node should be labeled “blue” (blue dye only), “hot” (radioactive only), or “hot and blue.”

If multiple nodes are identified on preoperative images, every attempt should be made to identify and remove multiple sentinel nodes. Once all sentinel nodes have been removed, the gamma probe should be used to confirm that there is no further radioactivity in the groin. The Scarpa fascia and skin can then be closed. If only sentinel nodes are removed, no drain placement is necessary.

### Complications and Morbidity

Intraoperative complications and morbidity are rare. There is a small risk of hemorrhage; however, sites of potential bleeding should be easily anticipated and controlled with ligatures before transection. If hemorrhage is encountered because of the superficial nature of the dissection and lack of major vessels in the operative field, control of bleeding is usually easily achieved with small clamps and suture ligatures.

The two most common short-term (<30 days) postoperative complications are surgical site infection and wound separation. Wound separation occurs in up to 50% of patients. Management of uninfected wound separations typically involves allowing the wound to heal through secondary intention. Infection of surgical sites occurs in almost one-third of patients and should be managed with oral antibiotics.

The most common long-term (>30 days) complications are lymphocyst formation and lymphedema. For women undergoing complete inguinal lymphadenectomy, lymphocyst may occur in up to 29% of patients. Small, asymptomatic lymphocysts can be managed conservatively with observation or aspiration. Large, symptomatic lymphocysts should be managed with replacement of the drain and may require sclerosing if they remain unresolved. Lymphocysts that do not resolve with long-term drainage or sclerosis may require open drainage through a large incision of the groin and healing through secondary intention.

Lymphedema occurs in almost two-thirds of women after complete inguinal lymphadenectomy (Fig. 4.15). However, if only sentinel lymph node biopsy is performed, the rate of lymphedema is reduced to less than 2%. When complete inguinofermal lymphadenectomy is required, sparing the saphenous vein will greatly reduce the risk of lymphedema. For women who have symptomatic lymphedema, elevation of the affected extremity, compression stockings, and physical therapy may help manage symptoms. Some women may be candidates for microvascular lymphaticovenular anastomosis or lymph node transfers; however, these techniques remain early in their development.

### References

17. Wooldrinking JM, de Bock GH, de Hullu JA, Davy MJ, van der Zee AG, Mourits MJ. Patterns and frequency of recurrences of squamous cell carcinoma of the vulva. Gynecol Oncol. 2006;103:293–299.
The standard treatment for women with early-stage cervical cancer (stages IA2–IB1) remains radical hysterectomy with pelvic lymphadenectomy. In select patients interested in future fertility, radical trachelectomy with pelvic lymphadenectomy is also considered a viable option. Data from retrospective studies have confirmed that oncologic outcomes of radical hysterectomy and radical trachelectomy are equivalent.

Radical Trachelectomy

According to the National Cancer Institute, 40.1% of cervical cancers are diagnosed in women aged 20 to 44 years; specifically, 14.3% of cancers are identified in women aged 20 to 34, and 25.8% are diagnosed in women aged 35 to 44. Therefore an increasing number of nulliparous women who desire future fertility are at risk of cervical cancer. In 1994, Dargent and colleagues introduced the radical trachelectomy as a fertility-sparing option for women with early-stage cervical cancer. Since the inception of use radical trachelectomy in clinical practice, studies have described rates of recurrence (5%) and morbidity and mortality similar to those of radical hysterectomy, leading to the conclusion that radical trachelectomy is a viable, fertility-sparing management option for early-stage cervical cancer.

Abu-Rustum and Sonoda analyzed a prospectively maintained database of all patients with International Federation of Gynecology and Obstetrics (FIGO) stage IA1 to IB1 cervical cancer admitted for planned fertility-sparing radical abdominal trachelectomy. From November 2001 to May 2010, 98 consecutive patients with FIGO stage IA1 to IB1 cervical cancer and a median age of 32 years (range, 6–45 years) underwent a fertility-sparing radical trachelectomy. The most common histologic findings were adenocarcinoma in 54 patients (55%) and squamous carcinoma in 42 (43%). Lymphovascular invasion was seen in 38 patients (39%). FIGO stages included IA1 (with lymphovascular invasion) in 10 patients (10%), IA2 in 9 (9%), and IB1 in 79 (81%). Only 15 (15%) needed immediate completion radical hysterectomy because of intraoperative findings. The median number of nodes evaluated was 22 (range, 3–54), and 16 (16%) patients had positive pelvic nodes at final pathologic review. Final tracheectomy pathologic findings showed no residual disease in 44 (45%) patients, dysplasia in 5 (5%), and adenocarcinoma in situ in 3 (3%). Overall, 27 (28%) patients needed hysterectomy or adjuvant pelvic radiation postoperatively. One (1%) documented recurrence was fatal at the time of writing. It was thus concluded that cervical adenocarcinoma and lymphovascular invasion are common features of patients selected for radical trachelectomy and that most patients can undergo the operation successfully, with approximately 65% having no residual invasive disease; however, nearly 27% of all selected patients will require hysterectomy or postoperative chemoradiation for oncologic reasons.

Diaz and co-workers compared the oncologic outcomes of women who underwent fertility-sparing radical trachelectomy with the outcomes of those who underwent radical hysterectomy for treatment of stage IB1 cervical carcinoma. Forty stage IB1 patients underwent radical trachelectomy, and 110 patients underwent radical hysterectomy. There were no statistical differences between the two groups for the following prognostic variables: histologic findings, median number of lymph nodes removed, node-positive rate, lymphovascular space invasion (LVSI), and deep stromal invasion (DSI). The median length of follow-up for the entire group was 44 months. The 5-year recurrence-free survival (RFS) rate was 96% for the radical trachelectomy group compared with 86% for the radical hysterectomy group ($P =$ nonsignificant [NS]). On multivariate analysis in this group of stage IB1 lesions, tumor size of less than 2 cm was not an independent predictor of outcome, but both LVSI and DSI retained independent predictive value ($P = .033$ and $P = .005$, respectively). The authors concluded that for selected patients with stage IB1 cervical cancer, fertility-sparing radical trachelectomy appears to have oncologic outcomes that are similar to those of radical hysterectomy.

Indications

In general, radical trachelectomy is indicated in patients interested in future fertility who have been diagnosed with early-stage cervical cancer (IA2–IB1). Tumor histologic findings are another important factor in patient selection when this procedure is considered. The literature shows that patients with...
Squamous carcinoma, adenocarcinoma, or adenosquamous carcinoma are ideal candidates. High-risk histologic subtypes are considered, in general, to be contraindications to the procedure. These subtypes include small cell carcinoma, papillary serous carcinoma, undifferentiated carcinoma, or sarcoma. Equally important is selection based on tumor size, and ideal candidates are those with tumors smaller than 2 cm. The reason for this restriction is that it has been shown that the recurrence rate for tumors smaller than 2 cm after radical trachelectomy is 3% to 5%; however, when the procedure is performed in patients whose tumor size exceeds 2 cm, the recurrence rate can reach 15% to 25%. Other factors, such as tumor grade, are considered in the decision process before radical trachelectomy is recommended; however, it has been shown that the procedure is safe even in patients with poorly differentiated tumors, as long as selection is carefully based on the histologic subtype. Another element that is often a topic of discussion when considering indications for radical trachelectomy is the issue of LVSI. Although the risk of lymph node metastases in patients with positive LVSI is higher than in patients who do not have this finding, it has been shown that LVSI alone should not exclude a patient from consideration for radical trachelectomy. The literature shows that approximately 8% to 80% of all patients who have undergone radical trachelectomy have evidence of LVSI, and their risk of recurrence is not higher than the risk in patients without LVSI54 (Box 5.1).

A survey of the Society of Gynecologic Oncology (SGO) membership shed some light on the current patterns of practice pertaining to radical trachelectomy.7 Half of practitioner respondents reported having performed a radical trachelectomy, with 70.7% reporting a frequency of one or fewer radical trachelectomies in a year. Practitioners who did not perform radical trachelectomies gave various reasons, such as lack of training (53.4%), patients without medical indication (49.6%), and patients not desiring the procedure (39.1%). The majority of practitioners used a robotic (47.0%) or abdominal (40.5%) approach, with vaginal (15.8%) and laparoscopic (6.0%) radical trachelectomy being less common.

Preoperative Evaluation
All patients being considered for a radical trachelectomy must meet the aforementioned criteria. In addition, patients in whom there is not a gross visible lesion in the cervix, before the procedure the surgeon must ensure that the patient has undergone a conization to document evidence of invasive disease. In patients in whom there is a cervical lesion present at pelvic examination, a biopsy must be performed and then careful attention must be paid to the size of the lesion to ensure that the tumor size does not exceed 2 cm.

The preoperative evaluation of the patient must also include imaging studies to ensure that there is no evidence of metastatic disease. In general, a chest radiograph should suffice to ensure that there is no obvious evidence of metastatic disease in the chest. If there is suspicion of disease in the thorax, then a computed tomography (CT) scan of the chest is recommended. Traditionally, the pelvic imaging study recommended before radical trachelectomy has been pelvic magnetic resonance imaging (MRI).8 MRI provides several important details in patients with a diagnosis of early cervical cancer. These include tridimensional diameters of the lesion, uterine and cervical lengths, the degree of stromal invasion, distance from the internal os, and the presence of extracervical or nodal involvement. Parametrial involvement is present in 6% to 13% of patients with stage IB1 tumors.9 However, one must note that these percentages are inclusive of tumors up to 4 cm. Factors that may potentially correlate with parametrial involvement include lymph node status, size of tumor, DSI, stage, LVSI, grade, histology, and presence of residual tumor.

The use of positron emission tomography–computed tomography (PET-CT) is not routinely recommended, given the fact that patients who are candidates for radical trachelectomy are at such a low risk of metastatic disease that this imaging modality is not cost-effective in this setting. A recent study was performed to assess the clinical benefit of PET-CT in evaluating pelvic lymph nodes in patients with early-stage cervical cancer (FIGO stage IA–IB1) who had MRI-defined lymph node–negative disease, with histopathologic results as the reference standard.10 A total of 179 patients were evaluated; 47 of these patients had early-stage disease with no suspicious lymph nodes at MRI. The median age of patients was 48 years (range, 22–86 years). The median number of nodes dissected per patient was 21 (range, 8–47); 2 of 47 patients had nodal metastases (4.2%). All patients in this group had no suspicious lymph nodes on PET-CT. Overall patient-based sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of PET-CT for detection of nodal disease were 0%, 100%, 0%, 96%, and 96%, respectively. The authors concluded that PET-CT should not have a role in the routine pretreatment evaluation of patients scheduled to undergo radical trachelectomy.

It is interesting to note that in the survey of the SGO on the patterns of practice with regard to radical trachelectomy, responding practitioners reported that PET-CT scan was the preferred preoperative imaging method. This was performed instead of MRI by 71.0% of practitioners (55.5%).7

Surgical Approaches
Radical trachelectomy through several surgical approaches has been shown to be safe and feasible. The overwhelming majority of radical trachelectomy procedures reported in the literature have been performed through the vaginal approach. This approach allows patients to have a much faster recovery and quicker resumption of daily activities when compared with the open abdominal approach. The results are very favorable from both the oncologic and the obstetric perspectives. The second most common approach described in the literature is the abdominal approach. This route offers the advantage that it does not require surgeons to have undergone specific training in radical vaginal procedures. In addition, it has been suggested that the abdominal approach be considered in patients who have larger tumors because the one distinctive
difference between the vaginal and abdominal approaches is that in patients who undergo vaginal radical trachelectomy (VRT), the parametria is generally smaller than in patients who undergo abdominal radical trachelectomy (ART). This suggests that for larger tumors the preferred approach should be the abdominal approach.

There has been increasing enthusiasm for minimally invasive surgical procedures. A number of investigators have reported on the safety and feasibility of robotic radical trachelectomy. When compared with the open approach, the robotic approach is associated with less blood loss, lower transfusion rates, faster hospital discharge, and earlier return to daily activities, without compromising operative time, adequacy of surgical specimens, or lymph node count. The laparoscopic approach has also been reported but with less frequency. Results from small case series seem favorable, but these series have been limited by small numbers of patients and short follow-up times.

**Vaginal Radical Trachelectomy**

A study involving one of the largest series of VRT procedures assessed oncologic, fertility-related, and obstetric outcomes in 125 patients. This series included patients with stages IA, IB, and IIA disease. The median age of the patients was 31 years, and 75% were nulliparous. The majority of the tumors were stage IA2 (21%) or IB1 (69%), and 41% were grade 1. In terms of histology, 56% were squamous and 37% were adenocarcinomas. LVSIF was present in 29% of cases, and 88.5% of the lesions measured 2 cm or smaller. The mean follow-up time was 93 months (range, 4–225 months). There were six recurrences (4.8%) and two deaths (1.6%) after VRT. The actuarial 5-year RFS rate was 95.8% (95% confidence interval [CI], 0.90–0.98), whereas it was 79% (95% CI, 0.49–0.93) in the group in which the VRT was abandoned (P = .001). Higher tumor grade, LVSI, and size greater than 2 cm appeared to be predictive of the risk of abandoning VRT (P = .001, P = .025, and P = .03, respectively). Tumor size greater than 2 cm was statistically significantly associated with a higher risk of recurrence (P = .001). The authors concluded that VRT is an oncologically safe procedure in well-selected patients with early-stage disease. Lesion size greater than 2 cm appears to be associated with a higher risk of recurrence and a higher risk of abandoning the planned VRT.

The oncologic safety of VRT was also addressed in a meta-analysis that compared VRT versus radical hysterectomy and included 587 women. The analysis showed that there was no significant difference between the two groups in recurrence rate (hazard ratio [HR] for radical trachelectomy vs. radical hysterectomy, 1.38; 95% CI, 0.58–3.28; P = .47), 5-year RFS rate (HR, 1.17; 95% CI, 0.54–2.53; P = .69), or 5-year overall survival rate (HR, 0.86; 95% CI, 0.30–2.43; P = .78).

Another study evaluated 320 patients with cervical cancer who underwent VRT and aimed to determine the pattern of cancer recurrence in such patients. A total of 10 of the 320 patients had recurrent disease. The recurrence appeared at a mean time of 26.1 months (range, 3–108 months) after VRT. Five patients died within 8.8 months (range, 4–15 months) after recurrence was diagnosed. Two of these five patients had distant metastasis at the time of recurrence. Five patients were treated successfully with surgical intervention, and four patients were treated successfully with chemotheraphy. It is interesting to note that none of the patients in that series had high-risk factors.

**Abdominal Radical Trachelectomy**

In 2013, Pareja and co-workers published a systematic review of the literature concerning patients with early-stage cervical cancer who underwent ART. A total of 485 patients ages 6 to 44 years were identified. The most common stage was IB1 (71%), and the most common histologic subtype was squamous cell carcinoma (70%). Operative times ranged from 110 to 586 minutes. Blood loss ranged from 50 to 5568 mL. Forty-seven patients (10%) had conversion to radical hysterectomy; 155 patients (35%) had a postoperative complication. The most frequent postoperative complication was cervical stenosis (n = 42 [9.5%]). The median follow-up time was 31.6 months (range, 1–124 months). Sixteen patients (3.8%) had disease recurrence. Two patients (0.4%) died of disease. A total of 413 patients (85%) were able to maintain their fertility. A total of 113 patients (38%) attempted to get pregnant, and 67 of them (59.3%) were able to conceive. Therefore the authors concluded that ART is a safe treatment option in patients with early-stage cervical cancer who are interested in preserving fertility.

The relapse rate after ART (3.8%) was similar to the previously reported rate after VRT (4.2%). The death rate after ART (0.4%) was lower than the previously reported rate after VRT (2.9%). However, one must take into account that VRT was performed in earlier years than ART, when the selection criteria were not as strict, and that VRT series included patients at very high risk of recurrence, such as patients with larger tumors and high-risk histologic subtypes.

**Minimally Invasive Radical Trachelectomy**

Minimally invasive surgical procedures offer patients the advantage of reduced blood loss and transfusion rates, faster return of bowel function, shorter length of hospitalization, and quicker return to daily activities. Over the past several years, the indications for minimally invasive surgery (MIS) have expanded, and advanced radical pelvic surgical procedures are currently frequently performed through either laparoscopy or robotic-assisted techniques.

The first laparoscopic ART procedure was reported by Lee and colleagues in 2003. The largest series to date was described in a study published by Park and co-workers who reported on 79 patients who underwent laparoscopic radical trachelectomy. The mean age of the patients was 31 years (range, 20–40 years) and the mean tumor size was 1.8 cm (range, 0.4–7 cm). After a median follow-up period of 44 months (range, 3–105 months), nine (11.4%) patients had experienced recurrence and one (1.3%) had died of disease. In that study, the authors showed that a tumor size greater than 2 cm (P = .039) and a depth of stromal invasion greater than 50% (P = .016) were significant risk factors for recurrence.

More recently, robotic surgery has enhanced the capabilities of laparoscopic surgery by offering three-dimensional visualization, improved ergonomics, and instrumentation that allows surgeons to increase their dexterity in the surgical field. The safety and feasibility of robotic radical trachelectomy have been previously demonstrated. The robotic approach has been previously compared with the open approach for performance of radical trachelectomy. In a study by Nick and co-workers, the investigators compared 25 patients who underwent open radical trachelectomy and 12 patients who underwent robotic radical trachelectomy. Patients undergoing robotic radical trachelectomy had significantly less blood loss than patients undergoing open radical trachelectomy (median estimated blood loss,
103 patients. Fifteen percent of patients were treated with pelvic radiotherapy and chemotherapy. The risk of pelvic lymph node metastases in patients with stage IA2 to IB1 tumors ranges from 5% to 15%. It is imperative that these patients are routinely followed up for at least 1 year before attempting to conceive, in order to ensure that there is not an immediate recurrence. Another point to consider is that patients may not have been followed up for enough time after radical trachelectomy for pregnancy to be detected, and thus publication of findings may have preceded the pregnancies, leading to a significant underestimation of the true pregnancy rate.

Speiser and co-workers reported their experience with 212 patients who underwent VRT and noted that 76 patients (35.8%) were planning a pregnancy when the data were collected (0–5 years after the procedure). These authors showed that the pregnancy rate for all patients after VRT was 24%. In the unselected population, 85.4% of patients conceive within 12 months if they are trying to conceive. In Speiser's study, 50 women had a total of 60 pregnancies and 45 live births during the study period. Of the women who were planning to conceive, only those who had already had fertility issues or failed to conceive before trachelectomy had problems afterward. Possible changes that might influence fertility that are potentially caused by the operation itself are reduced cervical mucus; adhesions; reduced blood flow through the uterus, fallopian tubes, and ovaries; and cervical stenosis. Of the 60 pregnancies in the study, five resulted in miscarriage in the first trimester; one woman had an ectopic pregnancy. The rate of first-trimester miscarriages after VRT was lower than the rate in the unselected population (8.4% vs. 14%–20%). In the second trimester, miscarriage was more common (three patients had a late miscarriage), and this rate is comparable with rates in the unselected population (5% after VRT vs. 4% in the general population). There is no suggestion that hormonal treatment to improve fertility alters the oncologic results of VRT.

Intraoperative Schema

Pelvic Lymphadenectomy and Lymphatic Mapping

The risk of pelvic lymph node metastases in patients with stage IA2 to IB1 tumors ranges from 5% to 15%. It is imperative that an evaluation of the pelvic lymph nodes be performed before radical trachelectomy is undertaken. Lymph nodes are removed from the level of the mid-common iliac vessels at the proximal border to the circumflex iliac vein distally, to the psoas muscle with the lateral femoral cutaneous nerve as the most lateral border of the dissection, and medially and inferiorly to the level of the internal iliac vessels and the obturator nerve. In general, if there is evidence of grossly enlarged or suspicious-appearing lymph nodes, these should be sent for frozen section evaluation; if they are determined to be positive for disease, then the procedure should be aborted because these patients are routinely treated with pelvic radiotherapy and chemotherapy.

The role of lymphatic mapping and sentinel nodes is not yet standard in patients with cervical cancer undergoing either radical hysterectomy or radical trachelectomy. A number of prospective studies have shown the safety and feasibility of sentinel node identification and lymphatic mapping in patients with early-stage cervical cancer. (See Chapter 6.)

Obstetric Outcomes

A number of factors are to be considered when one is interpreting the data on preservation of fertility and the obstetric outcomes in patients undergoing radical trachelectomy. The published literature indicates that not all patients who undergo radical trachelectomy ultimately are able to conceive or even to consider becoming pregnant. The reasons for this vary, given that patients may not prioritize pregnancy immediately after a diagnosis of cancer. Other patients may have been counseled to wait for at least 1 year before attempting to conceive, in order to ensure that there is not an immediate recurrence. Another point to consider is that patients may not have been followed up for enough time after radical trachelectomy for pregnancy to be detected, and thus publication of findings may have preceded the pregnancies, leading to a significant underestimation of the true pregnancy rate.

Speiser and co-workers reported their experience with 212 patients who underwent VRT and noted that 76 patients (35.8%) were planning a pregnancy when the data were collected (0–5 years after the procedure). These authors showed that the pregnancy rate for all patients after VRT was 24%. In the unselected population, 85.4% of patients conceive within 12 months if they are trying to conceive. In Speiser's study, 50 women had a total of 60 pregnancies and 45 live births during the study period. Of the women who were planning to conceive, only those who had already had fertility issues or failed to conceive before trachelectomy had problems afterward. Possible changes that might influence fertility that are potentially caused by the operation itself are reduced cervical mucus; adhesions; reduced blood flow through the uterus, fallopian tubes, and ovaries; and cervical stenosis. Of the 60 pregnancies in the study, five resulted in miscarriage in the first trimester; one woman had an ectopic pregnancy. The rate of first-trimester miscarriages after VRT was lower than the rate in the unselected population (8.4% vs. 14%–20%). In the second trimester, miscarriage was more common (three patients had a late miscarriage), and this rate is comparable with rates in the unselected population (5% after VRT vs. 4% in the general population). There is no suggestion that hormonal treatment to improve fertility alters the oncologic results of VRT.

When considering fertility preservation and success rates after ART, one must take into account that the overall fertility rates are influenced by a number of factors. These include, but are not limited to, a lower overall number of abdominal radical trachelectomies reported in the literature, shorter follow-up time in comparison with published series on VRT, and a potential for greater compromise in blood flow to the uterus, given the larger surgical specimen with the abdominal approach.

In the most comprehensive review of the literature on ART published to date, Pareja and co-workers compiled data on 485 patients who underwent this procedure. They noted that fertility was preserved immediately after ART in the great majority of patients undergoing the procedure: 85%, which was similar to the 91.1% rate of fertility preservation in previously reported series of VRT. In 72 (15%) patients, fertility was not maintained. The reasons were immediate conversion to radical hysterectomy (47 patients), postradical tracheectomy radical hysterectomy (6), and postoperative adjuvant radiotherapy and/or chemotherapy (19). Information on pregnancy outcomes
was available for 298 patients. A total of 113 (38%) patients attempted to conceive, and 67 of them (59.3%) were successful. Of all patients whose fertility was retained, 67 (16.2%) were able to conceive. There were 18 pregnancy losses (five occurred in the first trimester, nine occurred in the second trimester, and the timing was not reported for the remaining four). Forty-seven deliveries were reported—19 at term, 12 before 36 weeks, and 16 not specified. Of note, there were 10 pregnancies ongoing at the time of the published report. For ART, once patients become pregnant, the rate of successful delivery at term is similar to that previously reported for patients who have undergone VRT (62.6% for ART vs. 68.8% for VRT). The rate of pregnancy loss after ART (24%) appears to be lower than the rate previously reported for VRT (30%), but higher than the rate in the general population (12%).

Data on pregnancy rates and fertility preservation in patients undergoing radical tracheectomy with a minimally invasive approach are limited. In the largest series of laparoscopic radical tracheectomies published to date, Park and co-workers published a report on 79 patients who underwent this procedure. A total of 13 (16.5%) patients were able to conceive. A total of 17 pregnancies were reported in these patients (four missed abortions, seven preterm deliveries, and six full-term deliveries).

Cervical Conization or Simple Hysterectomy in Low-Risk Patients

A less radical surgical procedure may be appropriate not only for patients desiring to preserve fertility but also for all patients with low-risk early-stage cervical cancer. A number of studies have explored less radical surgical options for early-stage cervical cancer, including simple hysterectomy, simple tracheectomy, and cervical conization with or without sentinel lymph node biopsy and pelvic lymph node dissection.

Rationale for Conservative Management of Cervical Cancer

The rationale for conservative management of early-stage cervical cancer is that a number of studies have shown a very low rate of parametrial involvement in patients with early-stage disease who undergo radical hysterectomy.

Kinney and co-workers initially evaluated 387 patients treated for squamous cell carcinoma clinically confined to the cervix. Of these 387 patients, 83 (21.5%) had tumors with a depth of invasion greater than 3 mm but tumor diameter no greater than 2 cm. No patient in this subgroup had evidence of LVSI, and no patient in this subgroup had parametrial nodal metastases. Subsequently, several other groups published the findings of studies on the risk of parametrial spread in patients with early-stage cervical cancer. Covens and co-workers reported on 842 patients with stage IA1 through IB1 cervical cancer who underwent radical hysterectomy. The goal of the study was to determine the incidence and factors predictive of parametrial involvement and to identify a population at low risk for pathologic parametrial involvement. Thirty-three patients (4%) had pathologic parametrical involvement: 8 in the parametrial lymph nodes and 25 in the parametrial tissue (none had both). Compared with patients without parametrial involvement, those with parametrial involvement were older (42 vs. 40 years, \( P < .04 \)), had larger tumors (median, 2.2 vs. 1.8 cm; \( P < .04 \)), had a higher incidence of LVSI (85% vs. 45%, \( P = .0004 \)), were more likely to have grade 2 or 3 tumors (95% vs. 65%, \( P = .001 \)), had greater depth of invasion (median, 18 vs. 5 mm; \( P < .001 \)), and were more likely to have pelvic lymph node metastases (44% vs. 5%, \( P < .0001 \)). The incidence of parametrial involvement in patients (\( n = 536 \)) with negative lymph nodes, tumor size 2 cm or smaller, and stromal invasion of 10 mm or less was 0.6%.

Wright and colleagues aimed to determine factors predictive of parametrial tumor spread and to define a subset of patients at low risk for parametrial disease. A total of 594 patients with invasive cervical cancer who underwent radical hysterectomy were examined. Parametrical metastases were documented in 64 patients (10.8%). Factors associated with parametrial disease were high-risk histologic subtypes, advanced grade, deep cervical invasion, LVSI, large tumor size, advanced stage, uterine or vaginal involvement, and pelvic or paraaortic lymph node metastases (\( P < .001 \) for each). A subgroup analysis was performed to identify patients at low risk for parametrial spread. In women with negative nodes, no LVSI, and tumors smaller than 2 cm, the incidence of parametrial disease was only 0.4%.

Frumovitz and co-workers conducted a similar study in which the rate of parametrial involvement was determined in 350 patients who underwent radical hysterectomy. In that study, the overall rate of parametrial involvement was 7.7%. However, when the authors stratified for low-risk characteristics, they found that the rate of parametrial involvement was zero in the 125 patients who met the following criteria: adenocarcinoma, squamous cell carcinoma, or adenosquamous carcinoma; tumor size smaller than 2 cm; and no LVSI.

The compiled data from these studies demonstrate that in patients with low-risk characteristics, the rate of parametrial involvement was less than 1%. These findings led investigators to consider that perhaps there is a subset of patients with early-stage cervical cancer who are unnecessarily exposed to radical procedures such as radical hysterectomy or radical tracheectomy.

Summary of Data From Retrospective Studies of Conservative Management

According to a report by Ramirez and co-workers, 260 women with early-stage cervical cancer managed conservatively have been described in the literature. Of these women, 197 (75.8%) had a diagnosis of squamous cell carcinoma, and 59 (22.7%) had a diagnosis of adenocarcinoma; most women (80.4%) had stage IB1 disease. Follow-up time in the series analyzed by Ramirez and colleagues ranged from 1 to 168 months. At the time the reports were published, relapse had occurred in two patients, and one patient had died of recurrent disease. A total of 73 pregnancies were reported, with 46 deliveries documented and 8 pregnancies ongoing at the time of publication.

In considering the patterns of practice from the members of the SGO survey, it was noted that most practitioners (72.1%) believed that in the future there would be a role for less “radical” procedures than radical tracheectomy in the management of early-stage cervical cancer.

Prospective Trials of Conservative Surgical Management of Low-Risk Cervical Cancer

Three prospective trials are evaluating a conservative approach in patients with low-risk early-stage cervical cancer.

The first is a prospective multiinstitutional international trial [ConCerv [Conservative Surgery for Women with Low-Risk, Early Stage Cervical Cancer]] evaluating the safety and feasibility of performing conservative surgical procedures in women
with early-stage cervical cancer with favorable pathologic characteristics. The inclusion criteria include stage IA2 or IB1 disease, tumor size 2 cm or smaller, and squamous cell carcinoma (any grade) or adenocarcinoma (grades 1 or 2). Patients with high-risk histologic findings or LVSIs are excluded. Patients desiring future fertility undergo only cervical conization and pelvic lymph node dissection with lymphatic mapping. Patients not desiring future fertility undergo a simple hysterectomy and pelvic lymph node dissection. The primary objective is evaluation of the safety and feasibility of performing conservative surgical procedures in this group of patients. Secondary objectives include assessment of treatment-associated morbidity and quality of life in patients undergoing conservative procedures compared with historical outcomes in matched patients treated with radical hysterectomy. In addition, the sensitivity of lymphatic mapping and sentinel lymph node biopsy in the detection of pelvic node metastases is being estimated. The sample size for the study will be 100 patients across all participating institutions.

The second ongoing study of conservative surgery is a Gynecologic Cancer Intergroup trial led by Plante and colleagues. The study is known as the SHAPE trial (Radical Versus Simple Hysterectomy and Pelvic Node Dissection in Patients With Low-Risk Early Stage Cervical Cancer). This is a randomized trial comparing radical hysterectomy and pelvic node dissection versus simple hysterectomy and pelvic node dissection in patients with low-risk early-stage cervical cancer. The inclusion criteria are stage IA2 or IB1 disease, tumor size smaller than 2 cm, squamous cell carcinoma or adenocarcinoma, and less than 10 mm stromal invasion apparent with loop electrosurgical excision procedure (LEEP) and cone biopsy or less than 50% stromal invasion present on pelvic magnetic resonance images. All tumor grades are allowed, and patients with LVSIs are eligible. The exclusion criteria include high-risk histologic subtype (clear cell carcinoma or small cell carcinoma), stage IA1 disease, evidence of lymph node metastases or extraterine disease, neoadjuvant chemotherapy (NACT), pregnancy, and desire to preserve fertility. Patients are randomized 1:1 to the control treatment, which is a radical hysterectomy and pelvic lymphadenectomy, with or without sentinel node mapping (which is optional), or the experimental treatment, which is a simple hysterectomy with pelvic lymphadenectomy with or without sentinel node mapping. The primary objectives are to determine whether simple hysterectomy in patients with low-risk cervical cancer is safe and associated with less morbidity than radical hysterectomy and to determine whether overall survival is significantly different between the 2 arms of the study. The secondary end points include treatment-related toxic effects, extrapelvic relapse-free survival, overall survival, rate of sentinel node detection, rate of metastasis to the parametria, surgical margin status, pelvic node status, and quality of life. The total anticipated accrual is 700 patients.

The third ongoing trial is the multiinstitutional trial Gynecologic Oncology Group (GOG) and NRG Oncology protocol 278 (Evaluation of Physical Function and Quality of Life Before and After Nonradical Surgical Therapy [Extralateralized Hysterectomy or Cone Biopsy With Pelvic Lymphadenectomy] for Stage IA1 [LVSI+] and IA2–IB1 [≤2 cm] Cervical Cancer). The primary objectives are to determine the impact of nonradical surgical procedures on bladder, bowel, and sexual function and to determine the incidence and severity of lymphedema after such procedures. The secondary objectives are to investigate whether nonradical procedures are associated with better physical function and less toxicity compared with historical data on radical surgery; to evaluate the incidence and severity of treatment-related adverse events, including surgical complications, among the entire cohort and by treatment type; to evaluate changes in quality of life, cancer worries, and concerns regarding sexual and reproductive issues among the entire cohort and by treatment type; to explore the relationships among functional outcomes, adverse events, cancer worry, surgical complications, and overall quality of life; and to determine participants’ intention for conception, determine the fertility rate, and assess the reproductive concerns of women who have undergone cone biopsy and pelvic lymphadenectomy. The eligibility criteria include histologic diagnosis of squamous cell carcinoma, adenocarcinoma, or adenosquamous carcinoma of the cervix; stage IA1 (LVSI positive), IA2, or IB1 disease; tumor size 2 cm or smaller; and any grade. All patients must have undergone a cone biopsy or loop electrosurgical excision procedure with margins negative for carcinoma and high-grade dysplasia. Depth of invasion must be no greater than 10 mm. Similarly, patients must have no evidence of metastasis on MRI or CT scan of the pelvis and chest imaging. They must also have negative pelvic lymph nodes on final pathologic assessment. In this study, patients will be stratified according to their wishes regarding fertility to either cone biopsy and pelvic lymphadenectomy or simple hysterectomy and pelvic lymphadenectomy. The minimum sample size for this study is anticipated to be 200 eligible patients. Depending on results from interim analyses and feasibility assessments, this study may accrue up to 600 patients.

Conservative Surgery in Larger Cervical Tumors

There are no conclusive recommendations regarding the safety of radical trachelectomy in patients with 2- to 4-cm tumors. Several investigators have used NACT in patients with 2- to 4-cm tumors to reduce tumor size so that fertility preservation may be offered. However, no published study has compared outcomes between patients with cervical tumors 2 cm or larger who underwent immediate radical trachelectomy and those who underwent NACT followed by radical trachelectomy. A literature review by Pareja and co-workers compared outcomes of these two approaches. The main end points for evaluation were oncologic and obstetric outcomes. The fertility preservation rates were 79%, 85.1%, 89%, and 91.1% for ART (tumors larger than 2 cm), ART (all sizes), NACT followed by surgical intervention, and VRT (all sizes), respectively. The global pregnancy rates were 16.2%, 24%, and 30.7% for ART, VRT, and NACT followed by surgical intervention, respectively. The recurrence rates were 3.8%, 4.2%, 6%, 7.6%, and 17% for ART (all sizes), VRT (all sizes), ART (tumors >2 cm), NACT followed by surgical intervention, and VRT (tumors >2 cm).

Surgical Techniques

Abdominal (Robotic) Radical Trachelectomy

The patient is placed in the dorsal lithotomy position with a Foley catheter in the bladder and pneumatic compression stockings on the legs; prophylactic antibiotics and anticoagulation agents are administered in the operating room. The procedure can be performed via a midline vertical incision, Pfannenstiel, Maylard, or Cherney incision based on the surgeon’s preference. Alternatively, if a minimally invasive approach is being considered, the steps of the procedure are the same as described in
the following sections. The illustrations depicting ART in this chapter represent the robotic approach.

**Step 1: Exploration of the Abdomen**

Once the abdominal cavity has been entered, a careful exploration of the entire peritoneal cavity for evidence of intraperitoneal spread is undertaken. This includes inspection of the upper abdomen and all peritoneal surfaces. For women with cervical cancer, if metastatic disease is encountered, the procedure should be terminated and the patient reassigned to undergo chemotherapy and/or radiation.

**Step 2: Exposure of the Retroperitoneum and Pelvic Spaces**

Whether to transect the round ligament is operator dependent. The benefit is that it may allow for easier exposure to the paravesical space once the ligament has been transected. The potential disadvantage is that by transecting the round ligament, one may compromise uterine support. Once the round ligament has been divided, the retroperitoneal space is entered. To optimize future fertility, care must be taken to avoid clamping or damaging the utero-ovarian ligament, fallopian tubes, or cornua. In addition, the surgeon must remember that the infundibulopelvic ligaments with ovarian blood supply are to be kept intact for the entire procedure. Gentle blunt dissection in this avascular space is performed, and the external iliac vessels, internal iliac artery, and ureter are identified. A careful examination of the pelvic lymph nodes should be performed, and any enlarged or abnormal-appearing nodes should be removed and sent for frozen section evaluation. (See Chapter 6.)

The paravesical and pararectal spaces are then identified and dissected. The paravesical space is developed by placing anterior and medial traction on the superior vesical artery and dissecting the space lateral to that vessel. This avascular space is bordered by the obturator internus muscle laterally, the bladder medially, the pubis symphysis anteriorly, and the cardinal ligament posteriorly (Fig. 5.1). Care must be taken not to create an inadvertent cystotomy when exposing the paravesical space. Once the paravesical space is fully developed, then attention is directed toward the pararectal space, which is entered by dissecting between the ureter and internal iliac artery along the curve of the sacrum. This is an avascular space bordered by the internal iliac artery and levator ani laterally, the rectum medially, the sacrum posteriorly, and the cardinal ligament (parametrium) anteriorly (Fig. 5.2). The anatomic features of both the paravesical and pararectal space are then fully exposed (Fig. 5.3). After opening these spaces, the surgeon should ensure that there is no tumor infiltration of the parametria.

**Step 3: Uterine Artery Ligation and Ureteral and Parametrial Dissection**

The ureter is then freed from its medial attachments and “rolled” laterally (Fig. 5.4). Once identified, the uterine artery is dissected and ligated at its origin (Fig. 5.5). There is no consensus on whether ligating or sparing the uterine artery is required in this procedure (see the section on areas of controversy later). With gentle medial and upward traction, the surrounding parametrial tissue is mobilized en bloc with the ureterine vessels. In dissecting the deep portion of the parametrium, care must be taken not to disrupt the sympathetic nerve fibers innervating the bladder and rectum. As the parametrial tissue is mobilized medially (Fig. 5.6), the ureter is tunneled from underneath it
as the parametrial tissue is brought up over it. The “tunneling” of the ureter continues until its insertion into the bladder is reached (Fig. 5.7).

The vesicouterine peritoneal fold is then transected (Fig. 5.8). This often requires further mobilization of the bladder downward. Care must be taken not to perform an inadvertent cystotomy during this portion of the procedure. Backfilling the bladder may assist in deciding the best surgical plane, particularly in patients who have undergone prior pelvic surgical procedures or multiple previous cesarean sections.

Step 4: Colpotomy and Cervical-Parametrial Amputation

With the bladder, vesicouterine fold, and parametrium freely dissected and the ureters mobilized laterally, the rectovaginal space is developed. This approach mobilizes the rectum away from the vagina and exposes the rectovaginal space (Fig. 5.9). With adequate visualization of the lateralized ureters, the uterosacral ligaments can now be transected (Fig. 5.10).

The vagina is transected such that a 2-cm upper vaginal margin is included with the surgical specimen (Fig. 5.11). The cervix
is amputated approximately 1 cm distal to the cervicouterine junction (Fig. 5.12). The uterine fundus is then carefully mobilized to the upper abdomen, where it can gently be placed and retracted out of the operative field.

The cervix, parametria, and upper vaginal margin are then sent for frozen section evaluation. The endocervical margin should be tumor free at least 5 to 10 mm from the level of the tumor depending on institutional protocol. If the upper cervical margins are not free of disease or if the margins are close, then additional cervical tissue can be removed to achieve the appropriate margins.

**Step 5: Placement of Uterine Cannula and Cerclage**

Once adequate margins are confirmed, either a pediatric Foley catheter or a Smit sleeve (Elekta, Stockholm, Sweden) (Fig. 5.13) may be placed in the remaining uterine canal in an effort to reduce future cervical stenosis. The Smit sleeve is sutured to the uterus at the 3- and 9-o’clock positions with 4-0 chromic suture (Fig. 5.14). This remains in place for 21 to 28 days postoperatively. However, there is no consensus on whether placement of a Smit sleeve is necessary (see the section on areas of controversy, later). A cerclage using permanent suture (0-Ethibond) may then be placed in the lower segment of the uterus. It is important to ensure that the knot of the cerclage suture is placed on the posterior aspect of the uterus to decrease the risk of erosion into the bladder anteriorly. Similarly, there is no consensus on whether placement of a permanent cerclage is mandatory at the time of the radical trachelectomy (see the section on areas of controversy, later). The uterus is then sutured to the upper vagina with absorbable sutures. This may be performed with interrupted or continuous sutures. A 2-0 V-Loc barbed suture (Medtronic, Dublin, Ireland) may be used.

**Areas of Controversy**

As mentioned earlier, the usefulness of uterine artery preservation, cerclage placement, and postoperative mechanical prevention of cervical stenosis remains unclear. Some have hypothesized that ligation of the bilateral uterine vessels may reduce blood flow to the uterine fundus, thereby increasing the risk in subsequent pregnancies of premature birth and intrauterine growth restriction (IUGR). For that reason, some have advocated techniques that spare the uterine arteries during open \(^27,28\) or minimally invasive \(^29,30\) radical trachelectomy. However, no data exist that support a finding of adverse pregnancy outcomes with ligation of the bilateral uterine vessels because perfusion from the intact ovarian vessels provides sufficient vascularization to maintain a healthy fetus in utero. Therefore many surgeons advocate ligation of the uterine arteries as part of a complete parametrial resection during this procedure.\(^5,31,32\) A randomized study will likely never be performed, nor is the number of pregnancies and deliveries reported of a sufficient size to permit detection of a statistical or clinical difference in the two approaches. When computed tomography angiography (CTA) was used to evaluate blood supply to the fundus after bilateral artery-sparing radical trachelectomy, researchers found that only 12.5% of patients had bilateral patent uterine arteries, 43.6% had evidence of unilateral occlusion, and 43.6% had bilateral uterine artery occlusion.\(^32\) In the same series of patients, the authors found a higher percentage of pregnancies among patients who had undergone uterine artery ligation and resection than among those who had undergone uterine artery-sparing procedures. These data suggest that the ovarian vessels
alone are capable of providing enough blood supply to maintain pregnancies.

Another area of debate is whether cerclage should be performed at the time of radical trachelectomy. Although this step has been performed routinely in most radical trachelectomy series, lately there has been increasing concern that cerclage performed at the time of trachelectomy may lead to cervical stenosis, bladder irritation, erosion, and chronic discharge. Placement of a cerclage does appear to increase the risk of cervical stenosis. In one large series, 12 patients (12%) had cervical stenosis after ART. However, of those 12 patients, 11 (92%) had a cerclage placed at the time of primary operation. For all patients who had a cerclage placed at primary operation, 21% eventually developed cervical stenosis, compared with only 4% of patients who underwent ART without cerclage placement at the time of resection. However, because of the significantly foreshortened cervix remaining at the end of a radical trachelectomy, many argue that placement of a permanent cerclage at the time of operation is important for reduction in preterm labor and premature preterm rupture of membranes in subsequent pregnancies. The cerclage, in theory, provides mechanical support, preventing dilation of the cervical canal resulting from cervical incompetence with increasing weight and pressure from a growing fetus. In a series of 77 patients at Memorial Sloan Kettering Cancer Center who underwent radical trachelectomy and cerclage placement, 23 women became pregnant after the procedure. Approximately one-third of preterm deliveries and two-thirds of second trimester miscarriages occurred in women who had developed cerclage disruption owing to either dilation of a stenosed os or erosion of the cerclage that necessitated removal. All patients who carried their pregnancies to full term (≥37 weeks) had an intact cerclage—either the one placed during the initial surgical procedure or one that had been placed during a revision procedure. For that reason, the authors continue to recommend placement of a permanent cerclage at the time of initial operation. Furthermore, if a patient who has undergone radical trachelectomy has multiple pregnancies, revision of the cerclage after the first delivery should be considered. Half the preterm deliveries in the Memorial Sloan Kettering series occurred in women who had had a previous full-term pregnancy.
Chapter 5  Conservative Surgery in Early-Stage Cervical Cancer

As discussed earlier (see Areas of Controversy), suture may be used for the cerclage when patients experience amenorrhea after a radical trachelectomy. Some surgeons leave the intrauterine catheter in place for 3 days, whereas others leave it in place for 3 to 4 weeks. Other surgeons do not place an intrauterine catheter. The most frequent long-term, postoperative complication after radical trachelectomy was cervical stenosis (see Complications of Radical Trachelectomy); this is most likely associated with cerclage placement or failure to use tools or techniques that would prevent stenosis, such as an intrauterine cannula. Traditionally, a pediatric Foley catheter has been placed into the uterine cavity, and the tip balloon has been insufflated to hold the catheter in place. This Foley catheter commonly dislodges or falls out. For patients in whom the catheter stays in place, common complaints consist of pain, cramping, and copious discharge. Because of these issues, a Smit sleeve—a plastic tube with drainage perforations—may be used. The Smit sleeve is sutured to the cervical stump at the time of radical trachelectomy with 4-0 chromic suture. This is easily removed in the office or clinic at any time from 2 to 4 weeks after the operation. This change has led to significantly decreased complaints and increased duration of in situ retention of the dilating device. In addition, the Smit sleeve appears to better preserve a patent uterine canal. Nick and co-workers at MD Anderson Cancer Center showed that the rate of cervical stenosis before use of the Smit sleeve was 14%, compared with 0% after implementation of this new technique.15

Complications of Radical Trachelectomy

Intraoperative Complications

Overall, major intraoperative complications are seemingly rare, occurring in fewer than 1% of patients, but include massive hemorrhage, ureteral injuries, and external iliac injuries. The intraoperative complication rate for VRT has been reported to be 2.4%, and complications include cystotomy and uncontrollable bleeding.34 For laparoscopic-assisted VRT, bowel injury or ureteral injury or both were reported to have occurred in up to 10% of patients,13 but the series of patients was small (N = 21), and it is likely that the rate approaches that of the open and vaginal approaches as experience increases. For minimally invasive radical trachelectomy (laparoscopic or robotic), series remain small, but intraoperative complication rates appear to mimic those of the open and vaginal procedures. In one report of 42 patients who underwent minimally invasive radical trachelectomy, Vieira and colleagues encountered one bladder injury, for a major complication rate of 2.4%.16 Other short-term, postoperative complications such as infection, abscess, or antibiotic use also may occur. To date, there have been no intraoperative deaths reported for any approach.

Postoperative Complications

Cervical Stenosis

The most frequent postoperative complication of radical trachelectomy is cervical stenosis. For ART, cervical stenosis has been reported to occur after as many as 28% of the procedures, although most series on the open approach report a rate closer to 10%.5 Similarly, about 10% of patients who undergo vaginal and minimally invasive radical trachelectomy experience cervical stenosis.11,16 As discussed earlier (see Areas of Controversy), some have argued that cerclage placement may increase stenosis, whereas others maintain that stenosis rates are similar regardless of cerclage placement. For example, Wethington and co-workers have reported that 21% of patients who underwent cerclage placement experienced stenosis, compared with 2% of those who did not undergo cerclage placement. Other investigators, however, have not been able to equate cerclage placement with stenosis, and certainly the risk of preterm delivery and preterm premature rupture of membranes must be considered when one is deciding whether or not to place a cerclage. The use of a Smit sleeve may be the most effective strategy in reducing stenosis; Vieira and co-workers reported a cervical stenosis rate of only 4.3% in patients who underwent placement of a Smit sleeve, compared with 10.5% in patients who underwent placement of a pediatric Foley catheter and 8.3% in those who had no device placed in the cervical canal.16 The majority of these patients, however, had a cerclage placed.

Amenorrhea

Another frequently noted complication after radical trachelectomy is amenorrhea, which has been reported in 5% to 25% of patients.13 When patients experience amenorrhea after a radical trachelectomy, the initial workup should include an immediate evaluation to determine if the patient is pregnant, ascertained by a routine urine or serum pregnancy test. If pregnancy has been ruled out, then the patient should undergo a pelvic ultrasound examination to determine if there is any sign of cervical stenosis. This will manifest in the ultrasound examination as a dilated uterine cavity, most likely secondary to fluid consistent with blood. In this case, gentle cervical dilation may be attempted in the office; however, patients with cervical stenosis after radical trachelectomy may require ultrasound-guided dilation under anesthesia. If the endocervical canal is very narrowed, one may consider the use of lacrimal duct dilators to dilate the cervix and lower uterine segment. If cervical stenosis has been ruled out, then one must investigate for other routine causes of amenorrhea.

Cerclage Erosion

The overall rate of cerclage erosion after radical trachelectomy is approximately 2% (range, 0%–13%). Although placement of a cerclage is not absolutely mandatory at the time of radical trachelectomy, when one does place a cerclage it is very important to follow certain steps to avoid or decrease the likelihood of this complication. There is no evidence to support whether a specific type of suture is associated with a higher predisposition toward cerclage erosion. 0-Ethibond suture may be used for the cerclage placement. It is very important to ensure that the cerclage suture is placed at least 1 to 2 cm above the margin of the incision made to amputate the cervix. The reason for this critical step is that if the cerclage suture is placed lower than this point, the suture will lie in very close proximity to the uterovaginal anastomosis and thus run the potential risk of eroding through this incision into the vagina. If cerclage erosion occurs, the patient should be notified, but no further intervention is required and the cerclage should be left in situ.

Reoperation

Fortunately, the risk of reoperation in patients undergoing radical trachelectomy is less than 1%. However, published reports have described isolated cases in which reoperation was necessary. These include reports of patients who underwent a second...
operation for removal of the uterine fundus because of uterovaginal fistulas, fundal necrosis, or chronic pelvic pain.16

Conversion to Radical Hysterectomy

Patients should be counseled adequately ahead of the surgical procedure regarding possible adverse intraoperative and postoperative outcomes necessitating removal of the uterine fundus. In a large series of patients in whom ART was planned, 19% had the procedure aborted or converted to a complete radical hysterectomy.31 On inspection of the abdominal and pelvic cavity, if there is evidence of peritoneal carcinomatosis, the procedure should be abandoned, given that such patients need treatment with chemotherapy. In the setting of grossly involved or suspicious lymph nodes, the surgeon should send those lymph nodes for frozen section evaluation to determine if there is evidence of metastatic disease to those lymph nodes, and if such is the case, the procedure should be aborted because the treatment at that point is combined chemotherapy and radiation. In addition, when the frozen section of the surgical specimen is obtained, if there is evidence of a close margin (defined as <5 mm for squamous carcinoma and <10 mm for adenocarcinoma), then an attempt should be made to retrieve additional tissue from the residual cervix and this additional tissue should be sent to the pathologist for evaluation. If such margins are close or positive for disease, then a radical hysterectomy should be performed.

Key Points

- Oncologic outcomes of radical hysterectomy and radical trachelectomy are equivalent.
- Approximately 65% of patients have no residual invasive disease in the radical trachelectomy specimen.
- Approximately 10% of patients undergo conversion from planned radical trachelectomy to radical hysterectomy.
- Nearly 25% of all patients will require hysterectomy or postoperative chemoradiation for oncologic reasons after radical trachelectomy.
- Recurrence rate for tumors smaller than 2 cm after radical trachelectomy is 3% to 5%; however, when tumor size exceeds 2 cm, the recurrence rate can reach 10% to 25%.
- In approximately 75% of patients, fertility is maintained after radical trachelectomy.
- Approximately 38% of patients attempt to conceive after radical trachelectomy, and 60% are successful.
- Robotic radical trachelectomy is associated with significantly less blood loss and shorter hospital stay than open radical trachelectomy.
- For ART, the rate of successful delivery at term is similar to that for VRT.
- There are no conclusive recommendations regarding the safety of radical trachelectomy in patients with 2- to 4-cm tumors.
- The usefulness of uterine artery preservation, cerclage placement, and postoperative mechanical prevention of cervical stenosis remains unclear.
- Placement of a cerclage does appear to increase the risk of cervical stenosis.
- Major intraoperative complications are rare, occurring in less than 1% of patients, but include massive hemorrhage, ureteral injuries, and external iliac injuries.
- The most frequent postoperative complication after radical trachelectomy is cervical stenosis (10%).
- The rate of cervical stenosis is approximately 4.3% after use of a Smit sleeve, compared with 10.5% with use of a pediatric Foley catheter and 8.3% when no device is placed in the cervical canal.
- The overall rate of cerclage erosion after radical trachelectomy is approximately 2%.
- The risk of reoperation in patients undergoing radical trachelectomy is less than 1%.

References


In early cervical cancer (ECC)—that is, International Federation of Gynecology and Obstetrics (FIGO) stage IA to IIA1 disease, when the tumor is still limited to the cervix or the adjacent vagina—the most popular treatment is radical hysterectomy and pelvic lymphadenectomy. This provides a 5-year survival rate of 80% to 90% in patients without nodal involvement.

For the past 20 years, an attenuation of surgical aggressiveness in the management of ECC has occurred, given that more than 54% of cervical cancer cases are diagnosed in women younger than age 50 years (i.e., women of reproductive age). Dargent and colleagues have described the technique of radical trachelectomy for tumors smaller than 2 cm, thus resolving the issue of infertility after conventional radical hysterectomy. Less radical procedures have also been proposed to decrease treatment-related mortality. Another method to decrease the aggressiveness of the management of ECC with low potential for lymph node metastasis is to replace unnecessary lymphadenectomies with sentinel lymph node (SLN) biopsy whenever this is oncologically feasible and justified.

Lymph Node Involvement in Cervical Cancer

Although the FIGO staging system does not include lymph node evaluation, lymph node status is the main prognostic factor of ECC and a crucial factor in determining treatments. The 5-year overall survival (OS) rate for patients with ECC is 88% in the absence of nodal spread. This value drops significantly to 57% when lymph node involvement is demonstrated. The number and sites of metastatic nodes play a major role, especially when the paraaortic area is reached. The estimated 5-year survival rate decreased from 84.9% to 33.1% if more than one positive node was present. Similarly, the 10-year survival rate dropped from 84.9% to 26.5%. In terms of nodal distribution, in general, the survival rate drops when the common iliac and upper areas are invaded. The addition of radiation therapy or, more recently, chemoradiation has been proved to improve local control and even the survival rate.

Consequently, systematic lymphadenectomy may be performed in patients with ECC. On the other hand, the morbidity of lymphatic dissections has been underestimated for a long time. Longer operative times, perioperative complications such as vascular or neurologic injuries, and delayed morbidities such as lymphedema and lymphocysts occur frequently. In addition, postoperative ileus, venous thromboembolism, and prolonged hospital stay have been reported. The occurrence of these iatrogenic complications is not rare. Twenty percent of patients undergoing lymphadenectomy subsequently develop lower limb lymphedema that not only is an incurable condition but also carries a heavy psychological burden including anxiety, depression, and adjustment disorders.

Quality of life of patients cured of their cancer is now a major issue.

The reported frequency of nodal involvement ranges from 0% to 31% in patients with stage IA1 to IIA disease. Thus in the best case scenario, more than 70% of patients are undergoing unnecessary lymphadenectomy with all its potential complications, without any staging or therapeutic benefit. Another consideration is the low nodal burden. The median number of metastatic nodes is two in ECC, and in 22% to 38% of patients the nodal metastasis measures less than 2 mm. Most nodal metastases are located in the obturator and external iliac area. This is explained by the physiologic drainage of the uterine cervix, with a pathway going through the parametrium and terminating in the obturator and iliac nodes. However, alternative pathways, with direct drainage to the presacral and paraaortic areas, have also been described. The low prevalence of nodal involvement in these anatomic areas has made it difficult for authors to draw conclusions regarding the necessity of systematically sampling these areas. Finally, 10% to 15% of patients who are considered to be free of nodal metastasis will develop relapses emerging from lymphatic territories, showing that the positive node was not retrieved.

*The authors also wish to thank the following individuals for their contributions to this chapter: Charlotte Ngo, Myriam Deloménie, Chérázade Bensaid, Caroline Cornou, Léa Rossi, and Marie Gosset.
For all these reasons, a systematic lymphadenectomy in which nodes are harvested between anatomic landmarks and not according to tumor spread may not be appropriate for obtaining accurate information regarding nodal involvement.

SLN sampling is not an emerging concept. Cabanas and co-workers introduced it in 1977 for penile cancer; then it was applied to melanoma and breast cancer.22-24 In gynecology, Lev-enback and colleagues promoted the technique for use in vulvar cancer.25 A pioneer work by Echt and colleagues integrated the principle into the management of cervical cancer tumors.26 Later, many studies tried to evaluate the feasibility and diagnostic value of this technique for treatment of uterine cervical malignancies. Researchers subsequently reported on diagnostic accuracy and the use of safety rules to limit the risk of false-negative results.27,28

Cervical Cancer: A Candidate for Sentinel Lymph Node Mapping

The role of imaging techniques in the assessment of nodal metastasis and SLN detection was studied for a long time as researchers sought the optimal modality. In a major meta-analysis, Choi and co-workers compared all these techniques. The patient-based sensitivities of computed tomography (CT), magnetic resonance imaging (MRI), and positron emission tomography (PET) or PET-CT were reported to be 50%, 56%, and 82%, respectively, and the specificities of the same techniques were 92%, 91%, and 95%, respectively. A region- or node-based comparison of the same modalities showed sensitivities of 52%, 58%, and 54% and specificities of 92%, 97%, and 97%, respectively.29 Despite the superiority of PET or PET-CT over the other imaging techniques, performance remains modest when one considers the potentially broad role of this diagnostic modality in determining management and prognosis. The poor performance of these noninvasive techniques in the evaluation of nodal metastasis establishes the need for other methods.

The SLN is, by definition, the first chain node that receives primary lymphatic flow from a solid tumor.30 Accordingly, SLN mapping is based on the fact that lymphatic drainage occurs in a defined pattern away from a tumor. Following this reasoning suggests that if the SLN is negative for metastasis, then the node beyond that point should also be negative.31

SLN mapping cannot be applied to all solid tumors, but cervical cancer appears to be a reasonable candidate for many reasons. First, nodal metastasis in ECC is present in 0% to 16% of tumors smaller than 2 cm, a rate that reaches 15% to 31% in stage IB disease, implying that a vast majority of patients will not benefit from a systematic lymphadenectomy. Second, routine preoperative imaging still fails to enable accurate determination of nodal status in such patients, owing to the small size of the metastases.32 Third and most important, the lymphatic drainage in cervical cancer mostly follows well-defined pathways with some checkpoints that were once defined as “interrupting nodes” and are known today as SLNs.17,32 But alternative pathways do exist. For all these reasons, cervical cancer is an area of opportunity for the application of targeted SLN biopsy.

In addition, the tracers can be easily injected into the cervix—that is, around the tumor—making the SLN actually representative of the tumor drainage and not only of the organ.

Anatomy of the Cervix and Its Lymphatic Channels

The lymphatic drainage of the uterine cervix, which is a centrally located organ, was studied by anatomists and surgeons by use of a variety of dyes.33 Reports from Reiffenstuhl and from Plentl and Friedman described the lymphatic drainage system based on pathways. The most important route extends along the lateral parametrium to the obturator, external iliac, internal iliac, and common iliac lymph nodes. A second route is via the anterior channel that follows the vesicouterine ligament and extends to the interiliac lymph nodes, ending in the external iliac chain. Another route is the posterior channel that runs along the uterosacral ligament and drains in the common iliac, sacral, and paraaortic nodes. The normal drainage through these channels occurs in a stepwise progression, although exceptional variations do exist.34,35 Skip lymph node drainage in cervical cancer is considered to be a rare event, and paraaortic involvement comes after the sequential spread to pelvic and common iliac nodes.36 Spread through aberrant lymphatic channels is a potential explanation for this phenomenon.

Rouviere observed that there was a collector of the internal iliac pedicle that could pool directly to the common iliac area at the level of L5, and he theorized about the potential presence of an anastomosis between the uterine and cervical drainage systems that could spread metastasis at the level of L4 through the infundibulopelvic ligament.37 These ideas were supported by many other researchers who reported direct extension to the paraaortic nodes.38,39 Roughly, typical drainage systems were defined as those that followed the external iliac and interiliac basins, whereas other drainage routes were considered atypical.40 These anatomic data were also confirmed by many other authors, among them those who performed systematic lymphadenectomy and those who tried to standardize the surgical procedure. The conclusion from these studies is that removal of the nodes from the external iliac, interiliac, obturator, and common iliac territories will permit identification of most of the involved nodes. The information that lymphadenectomy provided over the years was at the basis of SLN sampling (Fig. 6.1).41

Efficiency of Sentinel Lymph Node Technique

To be considered efficient, SLN biopsy should have both a high detection rate and a high negative predictive value. The detection rate can be calculated as follows: at least one SLN detected per patient divided by the total number of patients injected. The negative predictive value per patient is the result of the following formula: true-negative SLNs divided by the sum of the true-negative and false-negative SLNs.

The development of the lymphatic system starts at the pelvic side walls at around 10 weeks of gestation; because the cervix is at the midline, lymphatic drainage occurs from the organ to the laterally situated plexuses.42 For this reason, SLN found in a hemipelvis will be predictive of the status of the remaining nodes on the ipsilateral side and does not represent the contralateral hemipelvis.43 This concept caused many oncologic surgeons to consider the hemipelvis to be a separate entity and to suggest that the sensitivity of SLN mapping techniques be calculated based on the hemipelvis as the unit of analysis, rather than on a per-patient basis.44,45
Detection rates varied significantly from one study to another, ranging from 15% to 100% per patient and from 43% to 97% when the hemipelvis was used as the unit of analysis. Major contributing factors were the FIGO stage, mapping technique, and surgeon's experience; a history of previous cone biopsy or preoperative brachytherapy did not affect this rate. Neoadjuvant chemotherapy (NAC) remains in a gray zone, with conflicting reports. The surgeon's experience is known to play a major role. Plante and colleagues and Seong and colleagues reported a relationship between the surgeons’ experience and an increase in SLN detection. Khoury-Collado and colleagues further supported this idea by stating that more than 30 cases are needed for the detection rate to increase from 77% to 94% in endometrial cancer. A retrospective analysis by Dargent and Enria showed that the average time to retrieve the SLN was 58.7 minutes for the first 35 patients, dropping to 35.5 for subsequent patients (P < .05). A study conducted by Hwang and co-workers showed that around 40 and 57 cases are needed per surgeon to achieve a turning point in operation time and complication rates, respectively.

The learning curve applies not only to the intraoperative detection of sentinel nodes, but also to the initial injection technique, lymphoscintigraphy interpretation, and pathologic assessment. As an example, Lantzsch and colleagues and Li and colleagues reported detection failure in patients who had received an inappropriate injection of the tracer substance. False-negative results and negative predictive value are sparsely assessed in the literature. Some of the findings may be related to the characteristic of the tumor and pelvic anatomy, and others to the application and analysis of the results. Hauspy and co-workers performed a review of the literature to assess the false-negative rate. When their results were combined with those of the previous studies, the rate of false-negative results was less than 2%. With regard to tumor characteristics, the first parameter was the initial tumor size and the second was lymphovascular space invasion (LVSI). Darlin and colleagues, in a study that included 105 patients with ECC (IA1–IIB) and in which the isotopic technique was followed, reported 100% negative predictive value in tumors smaller than 2 cm. A multicenter cohort study by Althassen and co-workers included 590 eligible patients and followed both the isotopic and colorimetric techniques; after systematic lymphadenectomy plus or minus paraaortic lymph node dissection was performed, the negative predictive value was 99.1% for tumors smaller than 20 mm, whereas it was a disappointing 94.3% for tumors larger than 20 mm. Slama and colleagues found an increase in false-negative rates in tumors measuring more than 20 cm² and those with LVSI in a study that included 225 patients with FIGO stage IA2 to IIB cervical cancer and in which ultrastaging was performed on SLNs.

In light of these findings, this technique was considered to be fully reliable only when the nodes are detected bilaterally, thus achieving the so-called “optimal mapping.” Cibula and colleagues, in a retrospective multicenter cohort study that included 645 patients with FIGO stage IA to IIB disease who underwent SLN biopsy and ultrastaging, described a 1.3% rate of false-negative findings when SLNs are detected bilaterally, thus reinforcing the results of SENTICOL. Based on this principle, an algorithm was described by Cormier and co-workers and the team at Memorial Sloan Kettering Cancer Center (MSKCC). In this algorithm, all mapped SLNs are submitted for pathologic analysis; when results of routine hematoxylin and eosin staining are negative, ultrastaging is performed. Suspicious nonsentinel lymph nodes are also removed and sent for analysis. If mapping is not achieved in a hemipelvis, a complete side-specific lymphadenectomy becomes necessary, not forgetting the parametrectomy that is performed by removal of tissue en bloc with the primary tumor specimen. This algorithm relies on use of the hemipelvis as a unit of analysis in order to improve the negative predictive value of SLN biopsy (96.8%) and to decrease false-negative results (7.4%) (see Fig. 6.1).
importance of the negative predictive value and false-negative rate resides in the fact that if a patient is incorrectly labeled as N0, she will not benefit from postoperative radiation therapy and will be at higher risk of recurrence.

False-negative results have been observed in biopsies of SLNs in all areas. However, the occurrence of false-negative findings in the parametrium has been a matter of debate. The problem starts with the difficult interpretation of the preoperative lymphoscintigraphy images, includes the intraoperative detection and the false isotopic signals, and ends with the microscopic analysis of these nodes. It is important to mention that debates are rising as to whether parametrial nodes should be considered part of the sentinel nodes. Frumovitz and co-workers performed a “triple injection” using radiocolloids, blue dye, and India ink to assess the lymphatic drainage in 20 patients with ECC who were treated with radical hysterectomy or trachelectomy. Pathologic processing of the parametrium and the removed nodes was also done. By following the patterns obtained from these injections, and because there were no parametrial nodes in 25% of the patients, the authors concluded that there was a direct route of drainage extending from the cervix to the pelvic nodes and bypassing the parametrical nodes. Thus these nodes may not be always considered as sentinel in women with ECC.

Whether the unit of analysis is per patient or per side is also important. A true false-negative result occurs whenever a metastatic lymph node is detected but the sentinel node is negative for tumor cells. Conversely, a negative SLN contralateral to a positive SLN is not necessarily a false-negative finding, because SLN status on one side of the pelvis does not predict the nodal status on the contralateral side. For this reason, many authors have underlined the importance of interpreting the results of SLN biopsy per side and not per patient.

The aim of the SLN technique is not only to replace the aggressive lymphadenectomy procedure but also to decrease the morbidities of the baseline hysterectomy or trachelectomy; this is another implicit advantage that is often forgotten. A study by Strnad and co-workers showed that the risk of parametrial involvement is minimal if cervical cancer infiltrates less than two-thirds of the cervical stroma and if SLNs are negative, whereas the risk reaches 28% when the result is positive. In other words, the SLN technique can be used as a guide to calibrate the extent of radical hysterectomy, making it possible to consider a modified radical hysterectomy, a nerve-sparing procedure, or a simple trachelectomy when SLN biopsy results are negative.

The efficiency of the SLN technique is not an absolute fact; rather, well-defined rules need to be applied in order to reach a reliable application of this technique and what is referred to as quality assurance. The first rule is related to preoperative selection of patients. A thorough clinical examination and accurate imaging and pathologic analysis are the most basic requirements. The aim of this exploration is to select tumors smaller than 2 cm without suspected nodal involvement and to stratify them based on their histologic characteristics: squamous versus glandular. The second rule is related to the medical team. The surgical and analytical team members must be trained in the interpretation of the preoperative images, such as lymphoscintigraphic images or, more recently, single-photon emission computed tomography—computed tomography (SPECT-CT) scans; the injection of the tracer, whether isotopic, colorimetric, or fluorescent; perioperative decision making according to the

![FIG. 6.2 The checklist for the application of sentinel lymph node (SLN) biopsy. SPECT, Single-photon emission computed tomography.](image)

MSKCC algorithm; and, finally, the definitive pathologic analysis that is the last factor affecting subsequent management (Fig. 6.2).

**Methodologies**

Three main techniques are used for the completion of SLN biopsy. They are classified according to the tracer’s nature: radioactive tracers, colorimetric dyes, and fluorescent dyes. These tracers can be injected preoperatively or intraoperatively based on their diffusion and detection times. For instance, the isotopic radioactive tracers can be injected at any time between 1 and 24 hours preoperatively, whereas the colorimetric and fluorescent dyes are detectable 10 to 20 minutes after the injection of the tracer. The amount of tracer injected ranges from 1 mL to 4 mL. The number of injections in the cervical stroma varies from two to four, and their locations may be at the 3- and 9-o’clock positions, the 3-, 6-, 9-, and 12-o’clock positions, or the 2-, 4-, 8-, and 10- o’clock positions based on the surgeon’s preferences and training (Fig. 6.3). Authors have also used superficial injections, deep injections, or both. Results appear similar whichever technique is used, making SLN biopsy a robust technique.

Experience is needed for the injection of the tracer. A wrongly performed injection can result in improper diffusion of the tracer—from no diffusion to extended diffusion that may mask the surgical field—and therefore suboptimal detection. The reported failure time is the time after which it becomes useless to look for labeled nodes; this ranges from 70 to 150 minutes.

**Radioactive Tracers, Lymphoscintigraphy, and SPECT-CT**

The most widely used radioactive tracer in cervical cancer is technetium 99m ($^{99m}$Tc)—sulfur colloid in the United States and
There are two main protocols: the short protocol, which consists of performing lymphoscintigraphy at a median time of 61 minutes after the injection of the tracer; and the long protocol, in which the imaging is performed after a 14-hour interval. In other words, making use of the radioactive tracer guidance can start preoperatively; dynamic lymphoscintigraphy can be performed 20 to 30 minutes after the injection of technetium, thus revealing the progression of lymphatic flow and making evident the SLNs that are present.

The importance of lymphoscintigraphy lies in its use to create a map that will guide the surgeon during dissection. Another potential benefit is that lymphoscintigraphy can be repeated postoperatively to check for residual radioactivity. It is worth mentioning that some authors do not agree on the relevance of dynamic lymphoscintigraphy. They consider that it adds no value to static lymphoscintigraphy because the low particle kinetics after injection makes it hard to visualize SLNs. The drawbacks of radioactive tracers and lymphoscintigraphy are the pain that is experienced by some patients because of the injection of the tracers, and the time and cost related to communicate with the nuclear medicine unit and to follow the safety protocols related to this type of radioactive material. In addition, the time that should elapse between the injection and the imaging procedure increases the length of stay, thus further increasing the cost of this intervention.

With regard to intraoperative detection, an audible sound emitted from the gamma probe indicates the presence of a “hot” node that should be selectively sampled. Ergonomic features and efficiency of probes should be assessed, because most procedures are now performed with a laparoscopic or a robotic approach.

**Lymphoscintigraphy Versus SPECT-CT**

Planar lymphoscintigraphy guides the surgeon to find the SLN. However, the two-dimensional axes are considered a limitation. The introduction of SPECT-CT came to fill this gap (Fig. 6.4). SPECT-CT is associated with a higher cost and more ionizing radiation, but it generates a cross-sectional anatomic reference with three-dimensional localization, thus providing more accurate spatial information. This seems interesting for some specific areas. The parametrium is a difficult area of interpretation in planar lymphoscintigraphy because of its proximity to the injection site and the shine-through effect. Another described advantage of SPECT-CT is its detection capacity at the level of the common iliac and aortic territories, which are known to be atypical sites. In a study by Martinez and colleagues, SLNs in these sites were found in 26.8% of the patients, thus exceeding the estimated known prevalence.

A review of the literature and meta-analysis by Hoogendam and colleagues involved a face-to-face comparison of planar lymphoscintigraphy and SPECT-CT. The report of eight studies showed detection rates for SPECT-CT ranging from 92% to 100%; in other words, SPECT-CT detection rates were superior to those of lymphoscintigraphy, with an odds ratio (OR) of 2.5 (95% confidence interval [CI], 1.2–5.3). Diaz-Feijoo and colleagues showed that SPECT-CT also detected more nodes per patient. The implication of all this intraoperatively gathered information is that SLN retrieval time was reduced by 25.4 minutes, as reported by Hoogendam and co-workers.

**Colorimetric Dye**

Colorimetric dyes are also used in the detection of SLNs in cervical cancer. Methylene blue, patent blue, and isosulfan blue are the most commonly used dyes. Not all three are biologically active compounds; the clearance of methylene blue occurs via the renal and hepatic system, whereas isosulfan blue is excreted through bile. Injection of these tracers is performed intraoperatively because of the rapid diffusion of the dye. The surgeon’s experience is again important for the injection of these dyes. If the dye dissipates into the paracervical tissue, it makes the dissection of planes a difficult task, thus hampering the detection and harvest of SLNs. A major concern with use of colorimetric dyes is adverse effects, such as allergic reactions and anaphylactic shock (<1%). An additional concern with isosulfan blue is that it is contraindicated in the context of phenylethene hypersensitivity.

**Fluorescence**

Fluorescence is the technique most recently introduced for the detection of SLNs in cervical cancer. This concept is not actually novel; it has been used in the evaluation of other...
malignancies—primarily gastric, anal, periocular, and breast cancers. Indocyanine green (ICG) is the most commonly used tracer. ICG fluoresces at 800 nm, is bound to plasma protein, has low toxicity, and is excreted through bile. An important aspect with fluorescence is the high signal-to-noise ratio, which facilitates the retrieval of SLNs (Fig. 6.5). The optimal dose of ICG to be injected ranges from 400 to 800 μM. van der Vorst and his team reported a dose of 500 μM when ICG was bound to human serum albumin. It is important to mention the rapid diffusion of the dye; because of this, the injection is better done after the induction of anesthesia. Plante and co-workers noted that fluorescence has an additional benefit in terms of cost; the authors compared fluorescence and the isotopic technique and found the former to be less costly, given the price of the injection and the probe, the costs associated with the lymphoscintigram, and the radiologist’s fees. Fluorescence is also less cumbersome because it is less demanding in terms of interpretation and scheduling issues, particularly with regard to the operating room. The first publication on the use of fluorescence in uterine malignancies was by Rossi and co-workers in 2012. The main aims behind the introduction of this technique were to spare patients the adverse effects of the conventional tracers, such as pain and allergic reactions, and to spare the hospital and patient the elevated cost associated with radiocolloid tracers, while also achieving at least the same level of performance. Finally the ergonomics of detection is improved: fluorescent SLNs are observed with a global view of the pelvis or paraaortic area, as opposed to blind detection with a rigid probe.
The Performance of the Detection Modalities

According to van de Lande and colleagues, the colorimetric technique has the poorest performance, with a sensitivity of 81%, followed by the isotopic technique and then the combination of colorimetric and isotopic techniques, with a sensitivity of 92%. Another review of the literature by Rasty and colleagues confirmed the results by van de Lande and colleagues. Use of blue dye resulted in detection rates of 84% (95% CI, 79%–89%); the detection rate was 88% when technetium was used and 92% with the combination of the two techniques.

A review article by De Greve included a comparison of the detection rates based on the technique. In four of seven studies, the isotopic technique was superior to the colorimetric technique. In two of seven, the findings were reversed, and in one study the two techniques had identical detection rates. In all the studies the combined method had the highest level of performance. A meta-analysis and systematic review of 49 studies from January 2000 through August 2013 with a total of 2476 SLN procedures included a subgroup analysis based on the tracer used. When technetium was used in conjunction with the blue tracer, the sensitivity was 0.88 and the detection rate was 0.97. When technetium alone was used, the sensitivity and detection rate dropped to 0.87 and 0.90, respectively, and they decreased to 0.87 and 0.87 when the blue dye was the surgeon’s choice. The same study compared the surgical modality used—laparotomy, laparoscopy, or robotic surgery—and found no statistically significant difference in sensitivity or detection rate.

A pilot study by Plante and co-workers clarified the performance of ICG. The overall detection rate for fluorescence was 96%, with bilateral detection rates of 88%. Two other studies, conducted by Rossi and colleagues and Jewell and colleagues, found detection rates ranging from 85% to 96%, with bilateral detection rates of 60% to 88%. Buda and colleagues compared fluorescence and the colorimetric dye methylene blue and found overall detection rates of 100% versus 84% (P = .041) and bilateral detection rates of 88% and 55%, respectively (P = .002). The preliminary results of an ongoing prospective study conducted in the European Hospital Georges Pompidou in France showed an obvious superiority of fluorescence over the isotopic technique. In this study, which included 15 patients with stage IA to IB1 cervical cancer, the overall detection rates and bilateral detection rates of fluorescence and technetium were 93.33% versus 86.66% and 93.33% versus 66.66% respectively.

Based on these results, it appears that fluorescence provides high detection rates and high bilateral detection rates, making its use a promising tool for the future.

Pathology Processing: Ultrastaging Immunohistochemistry and Polymerase Chain Reaction

Ultrastaging is defined as the analysis of SLNs by using serial sectioning and immunohistochemistry (IHC). Because histologic and molecular analysis is time-consuming, its use in the total lymphadenectomy specimen is cumbersome. This technique is usually directly coupled with SLN biopsy. Five wide hematoxylin and eosin–stained levels are performed at 250-μm intervals, with two unstained slides prepared for each level. If this wide cut is negative for disease, one unstained slide at each level is subjected to IHC with pancytokeratin. The main aim of this technique, which is applied to the SLNs that are negative on routine hematoxylin and eosin staining, is to detect occult metastases, believed by some to be partially responsible for the pelvic recurrences that develop in 15% of patients. Euscher and colleagues reported low volume metastases in up to 25% of patients. Gortzak-Uzan and co-workers evaluated the gold standard lymphadenectomy versus SLN technique coupled with ultrastaging. The result of this study favored the latter, with a twofold increase in detection rates. The potential explanation of this team is the extensive sectioning or ultrastaging that captured small metastatic loads in some SLNs. Because of the increased detection rate and because it reveals the real status of these “occult” nodes, the coupled SLN technique has better sensitivity, reinforcing its usefulness in ECC.

The skill of the pathologist and the processing methods used are crucial and will become the real rate-limiting factors; insufficient skill or an inappropriate method can eliminate the advantages of the SLN technique.

Most studies use IHC coupled with ultrastaging. IHC markers that were adopted are anti-cytokeratin (CK), AE1, and AE3, although some authors recommend anti-pancytokeratin KL1. Another keratin cocktail used is AE1/AE3, CAM 5.2, CK MNF116, and keratin 8 and 18. Lentz and colleagues found that IHC without serial sectioning permitted detection of micrometastasis in 15% of patients who had negative nodes on routine histologic assessment. Silva and co-workers also focused on the role of IHC in detecting micrometastasis in stage I and II cervical cancer. Another study, by Marchiole and colleagues, showed that IHC enabled detection of micrometastases in 23% of patients but at the price of a higher false-positive rate related to benign glandular inclusions. Concerning the performance of reverse transcription polymerase chain reaction (RT-PCR) and its ability to detect CK-19, contradictory reports have been given. Although some have supported the use of this method, others such as Yuan and co-workers have expressed a different opinion. This team believed that CK-19 expression overlapped between positive and negative SLNs and nonsentinel lymph nodes. A suggested alternative was the use of RT-PCR and the squamous cell carcinoma antigen (SCCA), which showed a higher specificity and was hence considered a better marker. When comparing RT-PCR and IHC, Marchiole and co-workers believed that the former had better sensitivity but a higher false-positive rate. Despite its performance, RT-PCR was not able to differentiate positive macrometastases from micrometastases or submicrometastases.

Impact of Size of Metastasis in the Sentinel Node

According to the American Joint Committee on Cancer criteria, macrometastasis is defined as deposits above 2 mm, and micrometastasis between 0.2 and 2 mm, while isolated tumor deposits (ITDs) are those inferior to 0.2 mm. Labeling an SLN as positive for malignancy has become insufficient; the nodal tumor size has implications for the overall prognosis. In colorectal cancer, for instance, Rahbari and co-workers in a meta-analysis showed that molecular detection of tumor cells in node-negative colorectal cancer had a deleterious effect on overall prognosis, disease-specific survival, and disease-free survival. In breast cancer, the presence of micrometastasis negatively affects the prognosis, but it was not demonstrated that ITDs have the same effect.
For ECC, the reports regarding prognostic value in terms of pelvic recurrence, OS, and disease-free survival are still conflicting, and the impact of ITD is still unclear, with a wide spectrum of deductions. Some authors believe that the presence of micrometastasis does not affect the recurrence rate. Stany and colleagues concluded that nodal micrometastasis did not increase the risk of recurrence and that this correlation persisted even after adjuvant radiation therapy was controlled for. Some authors consider that micrometastases are not even strongly associated with poor prognostic factors. Other authors believed that the presence of micrometastasis confers a poorer outcome in terms of recurrence and survival, but that this is a result not of the presence of micrometastasis per se, but rather of its association with other poor prognostic factors. Juretzka and colleagues found that micrometastases in ECC likely exist in patients who initially have poor prognostic factors such as LVSI, tumor size greater than 4 cm, deep stromal invasion, parametrical involvement, and histologic grade, and therefore these patients are candidates for a more aggressive management program that will include an additional adjuvant therapy. On the opposing side of the spectrum, many authors have found a negative correlation between the presence of micrometastasis and recurrence rate and/or OS. Marchiole and colleagues, in a study in which the majority of patients had stage IIIB disease, stressed the prognostic impact of micrometastasis on recurrence rates; they found a 2.5-times greater risk of recurrence when micrometastasis was present. In addition, Fregnani and co-workers found an inverse relationship between micrometastasis and progression-free survival and reported a 3.2-times greater risk of recurrence in the presence of micrometastasis when compared with absence of micrometastasis. Horn and co-workers concluded that micrometastasis is an independent prognostic factor with a 23% reduction in OS and described a relative risk of death of 2.5 when micrometastasis is present. Another study, by Cibula and colleagues, concluded that the detection of micrometastasis was associated with poorer prognosis, but that this was without a statistical significance when compared with absence of micrometastasis in terms of relapse-free survival. However, in the same study the association between micrometastasis and OS was statistically significant and comparable to the effect of a frank macrometastasis. However, Cibula and colleagues reported that ITDs did not have any prognostic implication. Along the same lines, a recent study by Colturato and colleagues found that the detection of micrometastasis did not increase mortality but suggested that the explanation was probably related to the short follow-up period, which was fixed based on the time of the surgical procedure rather than the time of relapse, and to the small sample size. This team found a strong association between micrometastasis and recurrence rate, with an 11.73-times higher risk. This suggests that patients with micrometastasis, especially if they have stage IB2 or IIA disease and stromal invasion greater than two-thirds, are candidates for adjuvant therapy to improve disease control and decrease the recurrence rate.

The relationship between the presence of micrometastases and the different prognostic aspects is still not fully established. The majority of reports to date have associated micrometastasis with a poor outcome in terms of recurrence, relapse-free survival, and OS. The clinical implication of such an association is the addition of an adjuvant therapy for all patients with detected micrometastasis—in other words, the application of the same protocols that are used for a frank macrometastasis.

In addition to micrometastasis, ITDs are the second subgroup of the entity called low-volume disease. The prognostic impact of ITD was assessed by Cibula and co-workers in a study that showed that the nodal tumor load was not associated with any significant risk in terms of OS or recurrence-free survival (RFS). Patients who had ITDs or negative nodes had comparable OS (P = .549) and RFS (P = .201), whereas RFS was longer than patients with micrometastasis (P = .008).

**Morbidity**

The initial impetus to replace conventional lymphadenectomy with SLN biopsy was the desire to minimize the associated morbidity of the former. For now, the assessment of SLN biopsy–related morbidities is still hard to assess because the major studies that were performed systematically completed their management by a lymphadenectomy or did not focus on the long-term complications. One remarkable study by Niikura and colleagues showed a decrease in lower extremity lymphedema after SLN biopsy when compared with lymphadenectomy (8.7% vs. 42%). Promising results are expected with the publication of the SENTICOL II results; this multicentric randomized controlled study primarily tackled the complications associated with these surgical procedures. The study, which included a total of 267 patients, compared the results and complications of pelvic lymphadenectomy versus those of SLN detection. Patients were assigned to two groups. In the first group, all patients underwent SLN biopsy followed by lymphadenectomy; the second group underwent only SLN biopsy. The preliminary results, which have been presented in meetings, showed a significant decrease in terms of lymphatic complications (P = .0065) and short-term neurologic morbidities (P = .001) among patients undergoing SLN biopsy as compared with those who underwent a complete lymphadenectomy.

**Typical and Unexpected Locations of Sentinel Lymph Nodes**

The old debate as to whether to stop the lymphadenectomy at the level of the pelvis or extend it further with the inclusion of the paraaortic territories could be resolved by the SLN technique. The lymphatic drainage of the cervix follows a defined path from the parametrium to the ilio-obturator area, then to the common iliac and the paraaortic territories. In a descending manner, SLNs are most commonly found in the ilio-obturator area (69% of patients), followed by the internal iliac and parametrium (11%) and finally the common iliac (7%). Despite this, anatomic variations do exist, giving rise to what is called “nodal jump,” which forms the basis of nodal relapses in patients assessed to have N0 disease in whom metastatic nodes erroneously were not removed during the conventional lymphadenectomy because of their atypical locations.

Based on the SENTICOL study, 80.6% of SLNs are located in the external and interiliac territories. Similarly, in the Marnitz classification, 70% of the SLNs are located in the interiliac territories; the proportion reaches 75% when the external iliac area is included. Irrespective of the tumor histologic characteristics, this pattern is preserved (Fig. 6.6). This distribution constitutes the classical scenario and has some practical implications; the detection should start in these areas but at the same time should not stop at this level because in 8% of patients the SLN is located...
in parametric, presacral, internal iliac, common iliac, and paraaortic sites (Fig. 6.7). The percentage of these atypical territories increases with the tumor stage; in stage IA, 3% of SLNs are located in the paraaortic area; this percentage increases at more advanced stages. Based on these facts and on analytical reasoning, if lymphadenectomy were performed instead of the targeted and selective SLN technique, some patients would be falsely tagged as N0 and would not benefit from adjuvant therapy. Hence, the importance of SLN biopsy lies in its ability to provide accurate information regarding the nodal status through efficient sampling of all these representative nodes from the expected and unexpected territories, thus achieving superiority over conventional lymphadenectomy. The advantage of the fluorescence and colorimetric dyes is that they visually guide the surgeon to the site of atypical nodes without previous knowledge provided by preoperative imaging techniques. With the high signal-to-noise ratio that is present with the fluorescence technique, the tasks gets even easier.

**Limitations of Sentinel Lymph Node Technique**

Intraoperative frozen section analysis constitutes the major limitation of SLN biopsy; fortunately, definitive pathologic processing and ultrastaging can compensate for this. The importance of having a sensitive frozen section analysis is that it permits one to treat patients with ECC with a single-step protocol. All studies in which attempts have been made to assess the reliability of intraoperative frozen section analysis have showed poor sensitivity of this technique not only for ITDs (although poor sensitivity in this case has not yet been shown to have any prognostic implications) but also for micrometastasis and macrometastasis. Slama and co-workers found a 56% sensitivity whenever all sizes of metastases were included. This poor performance was due to the inability of frozen section analysis to detect low-volume disease. When ITDs were excluded, the sensitivity shifted to 63%, which remains a modest value for such an important form of testing. In the same study the authors found that factors contributing to false-negative results were tumor volume greater than 20 cm³ and the presence of LVSI; parameters such as the tumor histologic type, patient age, and a history of NAC did not alter the results. The type of sectioning used during frozen section processing can alter the sensitivity. Gortzak-Uzan and colleagues adopted a new strategy in frozen section processing that involved serial perpendicular sectioning of the node along its long axis at 0.2- to 0.3-cm intervals. By following this strategy, they achieved better outcomes with this technique.

Because of the convenience of single-step management of ECC, several innovations have been suggested to improve the outcome of intraoperative assessment of SLNs and frozen section analysis. RT-PCR, cytokeratin 19 expression, and human papillomavirus (HPV) typing are examples being studied. The one-step nucleic acid amplification (OSNA) method seems a promising technique that needs to prove itself as a reliable technology that improves frozen section sensitivity.

With all the technological advances that have been introduced in the application of SLN biopsy, the access to appropriate facilities remains a major concern. It is well known that cervical cancer is a rare condition in developed countries, where it carries a low mortality rate; however, in developing countries it is still considered a major public health concern and is still the second leading cause of cancer-related deaths in the female population. It is reassuring to note that the concept and clinical application of the SLN technique are spreading worldwide, and the procedure is becoming available for all patients who are potential candidates for this type of procedure.

**Indications for Sentinel Lymph Node Detection**

The aim of SLN biopsy is to assess the nodal status, thus determining the subsequent adjuvant therapy; in other words, this technique should verify the absence of metastatic nodes in low-risk patients. It is believed that more than 95% of patients with cervical cancer.
stage IA cancers may not need lymphadenectomy; this number decreases in stage IIA disease. Because the probability of lymph node positivity does not exceed 31% at these stages, such patients are considered to be at low risk, and SLN technique is adapted to these patients. A limiting factor of SLN biopsy is tumor size. Meta-analysis has shown that detection rates, sensitivity, and negative predictive value all drop when the initial size of the tumor exceeds 2 cm from 94.5%, 100%, and 100% to 80.1%, 89.3%, and 94.9%, respectively; therefore the best candidates for node sampling are tumors smaller than 2 cm, but the technique is effective in tumors as large as 30 mm.

For achievement of optimal conditions for SLN detection and the best potential outcome, patients must undergo a thorough clinical examination and preoperative imaging, usually with MRI.

**Impact of Neoadjuvant Chemotherapy on Sentinel Lymph Node Detection**

The initial indication for SLN biopsy is a tumor smaller than 2 cm; for those larger than 2 cm or in patients who wish to preserve fertility, NAC can be an option. NAC may be followed by the SLN technique if the criteria for the latter are met. The main issue in such cases is the difficulty in extrapolating the outcomes from the standard scenario to cases in which NAC was used, and for this reason the results are still debated. Barranger and co-workers presented reassuring results, with similar outcomes whether patients received or did not receive NAC. Slama and co-workers have made similar arguments; moreover, they have suggested that NAC reduces nodal metastatic involvement with a potential elimination of low-volume disease. Kadkhodayan and colleagues, on the other hand, have suggested that results after NAC should be interpreted with caution. Thus the application of the SLN technique after NAC is still debated, and further studies are needed for additional clarification. Just as the general application of the SLN technique in cervical cancer was reinforced after its high negative predictive value and low false-negative rates were proved, if the application of this technique after NAC is to be justified, future studies should include systematic lymphadenectomies to assess these variables, in addition to a prospective follow-up of patients to determine data regarding OS and disease-free survival.
Technical Application and Suggested Algorithm

The steps performed in a majority of referral centers are quite similar. Selection of patients is performed according to clinical stage, histologic type (only squamous cell carcinomas and adenocarcinomas have been included in the published series), and MRI findings (largest diameter of the tumor, absence of suspicious node). All the technical steps should be performed by a surgeon trained in the technique (or by a surgeon in training under the direct supervision of a senior surgeon). If the surgeon has opted for an isotopic injection, the surgical team should verify that the injection was performed preoperatively according to either the short or the long protocol. If the colorimetric or the fluorescence method is to be used, the cervical injection should be performed with the patient under general anesthesia and before docking of the robot or the insertion and insufflation of laparoscopic trocars. The injection sites at the level of the cervix vary among teams; a suggested technique consists of two injections at the 3- and 9-o’clock positions for patent blue and ICG dyes. The surgeon must check the results of the preoperative lymphoscintigraphy or SPECT-CT examination.

The operation starts with inspection of the abdominal and pelvic cavities along with the gutters and diaphragmatic doms looking for potential metastatic implants that can upstage the cancer, thus making the SLN technique inappropriate for the patient.

The SLN technique is initiated regardless of the methodology chosen by the team. If the isotopic technique is used, the gamma probe is inserted to detect the hot nodes; if the colorimetric method is preferred, then the surgeon follows the track of the dye to localize the sentinel node. With fluorescence, activation of the near infrared mode will reveal the lymphatic tract, which will lead the surgeon to the fluorescent sentinel node. After detection, opening of the peritoneum is performed and selective removal of the sentinel node is done; frozen section analysis is an option, despite its proven poor performance. Pathologic examination should also be performed by a pathologist trained in the analysis and ultrastaging of sentinel nodes.

An “optimal mapping” method has been described by surgeons at the MSKCC and is said to decrease the false-negative rate. In this algorithm, if detection is not achieved on a hemipelvis, then a side-specific lymphadenectomy is advised in order to obtain a representative specimen from this site, not neglecting the systematic parametrectomy.28 When this crucial principle is kept in mind and this algorithm is followed, the safety of the SLN technique as a lymphatic evaluation system is established.

Conclusion

SLN biopsy is a feasible technique, with a better safety profile than conventional lymphadenectomy. Not only does SLN biopsy derive the same information as conventional lymphadenectomy from the expected territories of metastatic nodes, but it also has expanded coverage to atypical areas that, if missed, could result in undertreatment in the short term and nodal recurrence in the long term. Because in this technique only the informative nodes are removed, it limits the number of irrelevant nodes, thus making ultrastaging a possible option. Adhering to certain criteria in SLN biopsy is very crucial; the golden rule is to achieve bilateral detection regardless of the methodology adopted. Based on the literature, fluorescence is a solid competitor to all the conventional detection techniques because it provides superior bilateral detection rates. Performing preoperative SPECT-CT along with fluorescence provides the optimal setting for the SLN technique. NAC and the interpretation of SLN results remains a question to be answered, and new techniques such as OSNA are now being examined in attempts to improve the performance of frozen section analysis to manage ECC with a one-step procedure.

However, despite all these data, SLN biopsy is not a standard of care in most guidelines and is only an option in others. A validation study is now needed to demonstrate that patients given a classification of “negative” at SLN biopsy have the same prognosis and at the same time a better quality of life than patients given a classification of “negative” after a traditional dissection.

References


Chapter 6 The Application of Sentinel Lymph Node Biopsy in Cervical Cancer


According to National Comprehensive Cancer Network (NCCN) guidelines, radical hysterectomy is the preferred treatment for patients with histologically confirmed stage IB1 to IIA1 cervical cancer who are not interested in future fertility. Radical hysterectomy requires comprehensive knowledge of pelvic anatomy and the relationship among vital structures such as the rectum, ureters, bladder, and pelvic vasculature and the vast pelvic neural network. The aim of this chapter is to present an overview of various topics of interest on radical hysterectomy, including indications for the procedure, preoperative workup, surgical approaches, a detailed description of surgical technique, and management of complications.

History of Radical Hysterectomy

The first radical hysterectomy was performed by John Clark and Emil Ries at Johns Hopkins Hospital. Subsequently, Ernest Wertheim performed his first radical hysterectomy in 1898, and later, in 1911, he published the largest series at the time, on the abdominal approach, with more than 500 patients included in that report. The reported mortality rate and 5-year cure rate were 18.6% and 42.4%, respectively. In 1908 Schauta published the results of 564 vaginal radical hysterectomies, with a mortality rate of 10.8% and a 5-year cure rate of 39.7%. In 1921 Hidekazu Okabayashi described a more radical procedure, dissecting the ureters completely from their peritoneal attachment, allowing a broader lateral parametrial resection. Subsequently, in 1944 Alexander Meigs published his experience with radical hysterectomy and proposed that, given the high failure rates associated with radiotherapy at the time, radical hysterectomy should be the primary approach to patients with cervical cancer. In 1961 Kobayashi introduced the concept of nerve-sparing radical hysterectomy with a technique that involved a very detailed dissection of the hypogastric nerve in the medial leaf of the broad ligament, with a focus on sparing this structure and ensuring its bilateral preservation. This procedure had as its primary goal the prevention of postoperative bladder complications. Over the past 20 years, a laparoscopy or robotic approach has become increasingly more popular in the management of early-stage cervical cancer. Descriptions of the first laparoscopic and robotic radical hysterectomy (RRH) procedures were published in 1992 and 2006, by Nezhat and colleagues and Sert and Abeler, respectively. These minimally invasive approaches have shown benefit to the patient in terms of lower postoperative complication rates and faster return to daily activities. To date, there has been no prospective randomized trial that has evaluated whether minimally invasive surgery offers an advantage over laparotomy in the management of cervical cancer. An ongoing prospective randomized trial (LACC [Laparoscopic Approach to Cervical Cancer] trial) will, it is hoped, shed light on this question.

Classification of Radical Hysterectomy

The most recent classification of radical hysterectomy was published by Querleu and Morrow. In applying such a classification, several elements should be noted. These include the extent of parametrial resection and the three parts of the parametria—anterior or ventral, posterior or dorsal, and lateral—with clear limits and landmarks for identification (see the discussion of surgical technique later in this chapter). The radicality may be different on each side of the pelvis, according to tumor growth or clinical presentation. One of the most important features offered by this classification system is that there are anatomic landmarks that must be recognized, in a reproducible way, thus allowing surgeons a uniformity in the approach to the procedure.

Type A Radical Hysterectomy

Type A radical hysterectomy corresponds to the extrafascial hysterectomy, which allows full removal of the pericervical tissue up to the attachment of the vaginal fornices. The ureter does not need to be unroofed. In this type of radical hysterectomy, the surgeon is not required to resect the ventral or lateral parametria, nor the dorsal parametria. The hypogastric plexus, therefore, remains fully preserved.

Type B Radical Hysterectomy

Type B radical hysterectomy corresponds to the modified radical hysterectomy. Identification of autonomic nerves is not
required, and the hypogastric plexus is fully preserved. With regard to the ventral parametria, the ureter is unroofed only in its course through the parametria, allowing for the resection of only a small initial part of the medial leaf of the ventral parametria. In the lateral parametria, as the ureter is unroofed, dissected from the cervix, and displaced laterally (but not dissected from the lateral or ventral parametria), the resection margin is at a medial aspect of the ureteral bed, thus allowing for the horizontal resection of about 1 to 1.5 cm of the lateral parametria. The ureteral artery, branching from the uterine artery at its crossing of the ureter, can serve as a helpful landmark and is usually easily identified and can be spared. The longitudinal (deep parametrial or vertical) resection limit is formed by a tangential plane of the vaginal cuff resection. In the dorsal parametria, the type B radical hysterectomy aims for horizontal resection of 1 to 2 cm dorsally from the cervix. The resection line corresponds to the amount of lateral parametria removed. Longitudinally, the margin of resection is at the level of the vaginal cuff; however, it is important not to dissect below the course of the ureter because this is where one will find the branches of the hypogastric plexus.

**Type C Radical Hysterectomy**

The Morrow and Querleu classification distinguishes between a type C1 procedure, which corresponds to the nerve-sparing modification, and the type C2 procedure, which aims for a complete parametrial resection. There are significantly distinct resection margins between the two types, particularly in the longitudinal (deep parametral or vertical) dimension, which are determined by the course of the main branches of the inferior hypogastric plexus in the type C1 procedure.

Type C1 requires separation of two parts of the dorsal parametria: the medial part, which entails rectouterine and rectovaginal ligaments, and the lateral laminar structure, also called mesoureter, which contains the hypogastric plexus. Furthermore, type C1 requires only a partial dissection of the ureter from the ventral parametria, which is usually asymmetric toward more extensive resection of the medial leaf of the cranial (above the ureter) part of the ventral parametria. In the type C2 procedure, the ureter is completely dissected from the ventral parametria up to the urinary bladder wall. Defining the resection limits on the longitudinal (deep parametral or vertical) plane is crucial for distinguishing between types C1 and C2.

With regard to ureteral dissection, in the type C1 procedure the ureter is unroofed and dissected from the cervix and from the lateral parametria but only partially from the ventral parametria (1–2 cm). The type C2 procedure requires complete dissection of the ureter from the ventral parametria up to the bladder wall.

**Lateral Parametria—Transverse (Horizontal) Resection Margins**

- C1 and C2: The lateral border is identical for both types, formed by the medial aspect of the internal iliac vein and artery.

**Longitudinal (Deep Parametrial or Vertical) Resection Margins**

- C1—vaginal vein (deep uterine vein): The deep parametrial resection margin is formed by the vaginal vein; thus the caudal part of the lateral parametria containing the splanchnic nerves is preserved.

- C2—pelvic floor (sacral bone): The resection line continues alongside the medial aspect of the internal iliac vessels and pudendal vessels caudally up to the pelvic floor. The pararectal and paravesical spaces are completely unified; the splanchnic nerves in the caudal part are sacrificed. Such deep resection allows for greater mobility of the lateral parametria, facilitating its complete removal.

**Ventral Parametria—Transverse Resection Margins**

- C1: Partial dissection of the ureter from the ventral parametria allows for resection of 1 to 2 cm of the ventral parametria.

- C2—urinary bladder wall: Complete dissection of the ureter from the ventral parametria is required, which allows for complete removal of the ventral parametria up to the urinary bladder wall; both medial and lateral leaves of the ventral parametria are resected equally.

**Longitudinal Resection Margins**

- C1: The resection line is formed by bladder branches of the hypogastric plexus located below the course of the ureter.

- C2: The resection line is formed by the level of the paracolpium and vaginal resection. Both cranial and caudal (below the ureter) parts of the ventral parametria are removed. Bladder branches of the hypogastric plexus are sacrificed; thus their identification is not required.

**Dorsal Parametria—Transverse Resection Margins**

- C1 and C2: The dorsal border is identical for both types, formed by the rectouterine ligament attachment to the rectum.

**Longitudinal Resection Margins**

- C1: Sagittal dissection of the hypogastric nerves from the rectouterine and rectovaginal ligaments is performed. The main branches of the hypogastric plexus must be preserved on the lateral part (mesoureter); the caudal limit of the rectouterine and rectovaginal ligaments is formed by the tangential plane of the vaginal cuff resection.

- C2: Complete resection of the dorsal parametria is performed deeply below the rectal attachment; thus branches of the hypogastric plexus are sacrificed.

**Type D Radical Hysterectomy**

Type D radical hysterectomy differs from type C2 radical hysterectomy only in the lateral extent of the lateral parametrial resection. Ureteral dissection and resection of both dorsal and ventral parametria are identical to those in the type C2 procedure. Laterally, however, the type D procedure entails ligation and removal of the internal iliac artery and vein, together with their branches, including the gluteal, internal pudendal, and obturator vessels.

Lateral parametrial resection requires ligation of the internal iliac artery and vein. Their removal, together with their branches in the lateral parametria, allows for further lateral extension of the resection. The lateral resection line is formed by the lumbosacral nerve plexus, piriformis muscle, and obturator internal muscle. This type of radical hysterectomy is rarely performed for locally advanced tumors.
Indications for Radical Hysterectomy

Currently, only patients with early-stage disease are considered ideal candidates for radical hysterectomy. The most common indications for abdominal radical hysterectomy (ARH) include the following:

- Stage IA1 cervical cancer with lymphovascular space involvement
- Stage IA2 cervical cancer in patients not interested in fertility preservation
- Stage IB1 cervical cancer
- Stage IA1 cervical cancer with lymphovascular space involvement
- After chemotherapy or radiotherapy for locally advanced disease (usually IIB cervical tumors)
- Stage IIA1 cervical cancer

Preoperative Evaluation

The staging for cervical cancer remains a clinic staging system, and thus all preoperative evaluation relies on use of a nonsurgical approach. The preoperative evaluation must include a thorough pathologic review by an expert in gynecologic malignancies. Routine preoperative blood work should include a complete blood count and chemistry profile, including renal and liver function tests. NCCN guidelines do not routinely recommend imaging studies other than a chest radiograph. However, whenever there is suspicion of metastatic disease, the patient should undergo computed tomography (CT) or magnetic resonance imaging (MRI). The accuracy in detection of metastatic nodal disease ranges from 83% to 90% for CT and from 86% to 90% for MRI; positron emission tomography–computed tomography (PET-CT) has a sensitivity of 75% to 100% and a specificity of 87% to 100%,[12]

Use of MRI has been proposed by a number of authors to rule out parametrial involvement in early-stage cervical cancer. Sensitivity ranges from 38.0% to 100% and specificity from 61.5% to 99.0%.[13,14] In a recently published paper, in 303 patients with stage IB or IIA cervical cancer treated with adjuvant radiotherapy or concurrent chemoradiotherapy following primary surgery for whom MRI scans were available, the authors reported a sensitivity and specificity of MRI for detecting parametrial involvement of 53.8% and 82.1%, respectively. Positive and negative predictive values were 38.4% and 89.6%, respectively. The accuracy of MRI for detecting parametrial involvement was 77.2%. There were 45 false-positive (14.9%) and 24 false-negative (7.9%) results. The authors concluded that MRI did not show enough reliability to predict parametrial involvement status, and the prognosis was not affected by the MRI results.[15]

In summary, routine imaging in patients undergoing radical hysterectomy is not recommended unless there is high suspicion of metastatic disease (e.g., patients with tumors larger than 4 cm or those with high-risk histologic types such as serous carcinoma, carcinosarcoma, or neuroendocrine tumors).

Surgical Approach

In performing a radical hysterectomy, there are several possible approaches, and which is used depends on innumerable factors. These include but are not limited to surgeon experience, patient preference, equipment availability, and patient body habitus. Different approaches by which radical hysterectomy can be performed include:

- Laparoscopic-assisted vaginal radical hysterectomy (LAVRH)
- Abdominal radical hysterectomy (ARH)
- Laparoscopic radical hysterectomy (LRH)
- Robotic radical hysterectomy (RRH)

Laparoscopic-Assisted Radical Vaginal Hysterectomy

LARVH is a procedure in which all dissections in the pelvic spaces, identification of landmarks, and radical resection are done via the vaginal route, according to the classic description of Schauta.[5] The laparoscopic portion of the procedure is used to perform the pelvic lymphadenectomy and occasionally resection of the adnexa. On completion of the lymphadenectomy, the surgeon will proceed with the vaginal portion of the procedure. Because of the fact that extensive training in radical vaginal surgery is needed, this procedure is rarely performed, and only a small number of centers routinely use this approach.

In a recently published meta-analysis,[16] Zhang and co-workers compared the results in 349 women who underwent LARVH and 445 women who underwent ARH. The analysis examined seven publications (four reports from prospective cohort studies and three from case-control studies). LARVH was associated with less blood loss (weighted mean difference [WMD], −237.45; 95% confidence interval [CI], −453.42 to −21.47), fewer wound-related complications (odds ratio [OR], 0.17; 95% CI, 0.05–0.61), shorter hospital stay (WMD, −2.01; 95% CI, −2.52 to −1.51), and longer operative time (WMD, 48.95; 95% CI, 42.08–55.82) versus ARH. There were no statistical differences with regard to number of lymph nodes retrieved, urinary-related complications, rectal injury, lymphedema, and oncologic outcomes.

Abdominal Radical Hysterectomy

Radical hysterectomy is the preferred treatment in the surgical management of patients with early-stage cervical cancer, and its cure rate (in the absence of indications for adjuvant therapy) is over 90%.[17,18] Radical hysterectomy offers several advantages over radiotherapy in that it preserves ovarian function in young patients, it allows for direct evaluation of the lymph nodes, it does not affect functional vaginal length, and it is associated with an acceptable morbidity profile. In a meta-analysis comparing three techniques of radical hysterectomy (abdominal, laparoscopic, and robotic), the authors examined 47 articles: 21 studies (1339 patients) of LRH, 14 studies of open radical hysterectomy (1552 patients), and 12 studies of RRH (327 patients). Mean sample size, age, and body mass index across the three types of radical hysterectomy studies were similar. Mean operation time across the three types of radical hysterectomy studies was comparable. Mean blood loss and transfusion rates were significantly higher in ARH compared with both LRH and RRH. Length of hospital stay associated with RRH was significantly shorter than with the other two methods. The mean number of lymph nodes obtained, rate of nodal metastasis, and positive margins across the three types of approaches were similar. Postoperative infectious morbidity was significantly higher among patients who underwent ARH compared with the other two methods, and a higher rate of cystotomy was noted in the LRH group. The authors concluded that minimally invasive surgery, especially RRH, may be a better and safe option for surgical treatment of early-stage cervical cancer.[19]
Among the advantages of the laparoscopic approach are less blood loss, lower transfusion rates, better cosmetic results, lower rates of adynamic ileus, faster return of bowel function, and overall faster recovery. A recent report also featured the safety and feasibility of outpatient radical hysterectomy by the laparoscopic approach.\textsuperscript{22}

**Robotic Radical Hysterectomy**

The first RRH was reported in 2006 by Sert and Abeler.\textsuperscript{8} To date, more than 1000 cases have been reported in the literature.\textsuperscript{23} In a meta-analysis of 26 nonrandomized studies (10 studies comparing RRH and ARH, 9 studies comparing RRH and LRH, and 7 studies comparing all three approaches) including a total of 4013 women (1013 RRH, 710 LRH, and 2290 ARH), RRH was associated with less estimated blood loss (WMD, 384.3; 95% CI, 233.7–534.8) and shorter hospital stay (WMD, 3.55; 95% CI, 2.10–5.00) than ARH. RRH was also associated with lower odds of febrile morbidity (OR, 0.43; 95% CI, 0.20–0.89), blood transfusion (OR, 0.12; 95% CI, 0.06–0.25), and wound-related complications (OR, 0.31; 95% CI, 0.13–0.73) compared with ARH. RRH was comparable to LRH with regard to all intraoperative and postoperative outcomes. The authors concluded that RRH may be superior to ARH with lower estimated blood loss, shorter hospital stay, less febrile morbidity, and fewer wound-related complications. RRH and LRH appeared equivalent in intraoperative and short-term postoperative outcomes, and thus the choice of approach can be tailored to the patient and surgeon.\textsuperscript{21}

**Surgical Assessment and Technique**

In preparation for the surgical procedure, all patients should undergo prophylactic antibiotics as recommended in the guidelines of the American College of Obstetricians and Gynecologists (ACOG).\textsuperscript{24} An open radical hysterectomy should be considered a “clean-contaminated” operation. It is important to ensure that all measures are taken to prevent thromboembolic events. These include routine use of pneumatic compression stockings. Use of preoperative heparin remains a subject of debate, although many centers elect for a standard dose (5000 units subcutaneously) of unfractionated heparin 2 hours before the procedure.

**Type of Incision**

The abdominal incision depends on the surgeon’s preference and training; choices include a standard vertical incision, a Pfannenstiel incision, a Maylard incision, or a Cherney incision. The vertical incision is likely the fastest and the one to offer the greatest access to the upper abdomen. There is no evidence that a lower transverse incision limits exposure, but the choice of each of these is certainly a matter of the surgeon’s preference. The Maylard and Cherney incisions offer the advantage of great exposure to the lateral pelvic sidewall; however, the former may be associated with a greater degree of postoperative pain, because the rectus muscle must be transected. In addition, with the Maylard incision the inferior epigastric vessels may potentially be sacrificed. The Cherney incision offers the advantage that the rectus muscle and its vasculature remain intact, but, given the fact that the muscle must be severed from its aponeurosis to the pubic bone, this incision may be associated with osseous infectious complications.

**Unexpected Nodal Disease**

On entry into the abdominal and pelvic cavity, a thorough evaluation must be performed to ensure that no metastatic disease is found. When there is suspicion of metastatic disease (nodal or peritoneal), a biopsy should be performed and the specimen sent for frozen section evaluation. There is no consensus in the literature regarding how to proceed in this clinical scenario. In 2010, Gray and colleagues\textsuperscript{25} published a retrospective study including 268 women with early-stage (IA2–IIA) cervical cancer, of whom 19 (7%) had an abandoned hysterectomy for grossly positive lymph nodes (84%) or pelvic spread of tumor (16%). These patients were compared with 44 patients with evidence of nodal involvement found after surgical intervention; both groups received adjuvant radiotherapy or chemoradiotherapy treatment. There were no differences in major morbidity between groups: 26% versus 34% (OR, 0.69; CI, 0.16–2.57; \(P = .789\)) in the abandoned and completed surgical groups, respectively. The recurrence rate was 37% versus 18% (\(P = .168\)) between the abandoned and completed surgical groups. Overall survival in the abandoned surgical group was 73% versus 80% in the completed surgical group (\(P = .772\)). The author’s conclusion was that abandoning a planned radical hysterectomy for unexpected metastatic disease may not worsen the outcome. Potter and colleagues\textsuperscript{26} compared 15 patients with stages IB and IIA invasive cervical cancer whose radical hysterectomies were aborted solely for reasons of pelvic lymph node involvement with a control group of 15 patients matched for tumor size and number of lymph nodes involved in whom radical hysterectomies were completed. Both groups were treated with radiation therapy (RT) postoperatively. Survival and local control were not different between groups (\(P = .81\) and \(P = .127\), respectively). The authors concluded that if RT is anticipated, completion of radical hysterectomy followed by RT appears to offer no advantage over RT with the uterus in place in patients with early-stage invasive cervical cancer and pelvic lymph node involvement. Leath and colleagues\textsuperscript{27} published a study that included 23 patients with cervical cancer in whom a radical hysterectomy was aborted (17 patients with stage IB1 disease, 4 with stage IB2, and 2 with stage IIA). The reasons for aborting the procedure were as follows: 11 patients had pelvic extension, 7 had positive pelvic nodes, and 5 had positive paraaortic nodes. All 23 patients received postoperative RT; in addition, 12 patients received concurrent chemotherapy consisting of platinum with or without 5-fluorouracil (5-FU). Four patients (17%) had radiation-associated complications. Six of 23 (26%) patients experienced a recurrence. The 5-year overall survival rate was 83%, with a median follow-up period of 59 months (range, 12–107 months). The authors concluded that an aborted radical surgical procedure does not significantly increase overall complications and that these patients still have a favorable prognosis with postoperative RT.

In 2005, Suprasert and colleagues\textsuperscript{28} evaluated the outcomes of patients with stage IB to IIA cervical cancer whose radical hysterectomy was abandoned because of positive pelvic nodes detected during the operation compared with those found to have positive nodes after the operation at final pathologic evaluation. Among 242 patients with planned radical hysterectomy and pelvic lymphadenectomy (RHPL), 23 (9.5%) patients had grossly positive nodes. Radical hysterectomy was abandoned, and complete pelvic lymphadenectomy was performed. Of these 23 patients, 22 received adjuvant chemoradiation, and the remaining patient received adjuvant radiation alone. Four patients with positive paraaortic nodes were additionally treated with extended-field irradiation. When compared with 35 patients whose positive nodes were detected after the operation,
Complications in both groups were not significantly different, but the 2-year disease-free survival was significantly lower in the abandoned radical hysterectomy group compared with the RHPL group (58.5% vs. 93.5%, P < .01). The authors concluded that the survival of patients with stage IB to II A cervical cancer whose radical hysterectomy was abandoned because of grossly positive pelvic nodes was significantly worse than that of patients whose node metastasis was identified after the operation. The reason suggested by the authors for this finding was that the patients in the abandoned radical hysterectomy group had worse prognostic factors. In 2000, Whitney and colleagues\(^9\) aimed to evaluate the frequency with which intended radical hysterectomy for cervical cancer is abandoned and the outcomes in those patients. A secondary evaluation of a prospective surgical pathologic trial was performed. There were 1127 patients with stage IB carcinoma of the cervix entered in Gynecologic Oncology Group Protocol 49. These patients were to undergo RHPL with analysis of pathologic findings, complications, and outcomes. At operation, 98 women had extrauterine disease and the proposed radical operation was abandoned at the discretion of the operating surgeon. Subgroups of patients with extrapelvic disease (30) and pelvic extension (26), including grossly positive pelvic nodes (12), other pelvic implants (8), and gross serosal extension (2), were identified. Sixty-three (93%) patients subsequently underwent pelvic RT and one or two intracavitary applications. Paraaoortic fields were added for eight patients who were found to have positive paraaoortic nodes. Five patients received radiotherapy and chemotherapy; four patients received chemotherapy alone. One patient declined any further therapy. The disease-free survival was shorter for patients whose radical procedure was abandoned than for patients who underwent radical hysterectomy. Among the abandoned operation patients, those with extrapelvic disease had the shortest progression-free interval and survival. The authors concluded that the morbidity of the radical hysterectomy is low even when followed by RT. However, no recommendations for optimal therapy can be made from this analysis. Richard and colleagues\(^10\) published an article based on the Surveillance, Epidemiology, and End Results (SEER) Program database from 1988 to 1998. They compared the 5-year survival rates for women with apparently early-stage cervical cancer who had undergone completed versus abandoned radical hysterectomy and had been treated with postoperative RT. Women with positive lymph node involvement who had undergone a complete pelvic and paraaoortic lymphadenectomy were compared for 5-year survival based on whether a radical procedure was abandoned or completed at the time of operation. All women received postoperative RT. From a cohort of 3116 women diagnosed with stage IB cervical cancer, 265 (8.5%) had positive pelvic lymph nodes and underwent a complete pelvic and paraaoortic lymphadenectomy. Of these women, in 163 the radical hysterectomy was completed, whereas it was abandoned in 55. Positive pelvic lymph nodes averaged 2.58 ± 2.37 in the completed radical hysterectomy group and 2.42 ± 1.63 in the abandoned radical hysterectomy group. Median follow-up was 6.42 years in the completed radical hysterectomy group and 5.75 years in the abandoned radical hysterectomy group. Five-year survival for the completed radical hysterectomy group was 69% compared with 71% in patients with abandoned radical hysterectomy (P = .46). The authors concluded that the treatment for patients with positive pelvic lymph nodes at the time of radical hysterectomy should be determined by overall morbidity of therapy because equivalent 5-year survival rates were found between the completed and abandoned radical hysterectomy groups.

**Step-by-Step Approach to Abdominal Radical Hysterectomy**

**Development of the Rectovaginal Space (Fig. 7.1)**

Although there are several options in the sequence of the steps in performing an ARH, one of them is to begin the procedure by developing the rectovaginal space. The reasons for doing so include the following:

- To protect and isolate the rectal wall. This is useful when adhesions are present at this level or in case of endometriosis.
- To identify the posterior vaginal wall. Once the posterior vaginal wall has been identified, the posterior resection margin is identified.
- To define the limits of the uterosacral ligaments and also to facilitate finding the hypogastric nerve.

**Development of the Pelvic Spaces**

The adnexal triangle is formed by the round ligament, the infundibulopelvic ligament, and the psoas muscle (Fig. 7.2). The first structure that should be identified is the superior vesical artery,
which lies medially, attached to the medial peritoneal fold. The space located lateral to this structure is the paravesical space. This space is limited medially by the superior vesical artery, laterally by the iliac vessels, anteriorly by the pubic bone, and posteriorly by the cardinal ligament. At the floor of this space, one should identify the fibers of the levator ani muscles. Development of the paravesical space allows for excellent exposure of the pelvic lymph nodes (Fig. 7.3).

The next step is the development of the pararectal space. This space is bound medially by the ureter, the posterior leaf of the broad ligament, and the uterosacral ligaments; laterally by the internal iliac artery; posteriorly by the sacral fascia; and anteriorly by the uterine vessels. This space is also known as the Latzko space. The uterine vessels must be carefully dissected from their origin in the hypogastric artery. One should note that in some cases there are two vascular structures together, the uterine artery and the superficial uterine vein, usually in a parallel position. The surgeon can identify the hypogastric nerve approximately 4 to 5 cm below the artery and attached to the peritoneum; this nerve lies in the inferior aspect of the pararectal fossa (Figs. 7.4–7.6).

With careful dissection, the surgeon can observe the branches of splanchnic nerves crossing the pararectal fossa to join the hypogastric nerve; together they will transform, below the deep uterine vein, into the inferior hypogastric plexus. At this point in the operation, the surgeon has dissected the first two spaces of the pelvis, and the pelvic side wall anatomy should be completely exposed.

The next step is identification and separation of the ureter from its attachment to the posterior leaf of the broad ligament. One must pay careful attention to ensure that the vasculature of the ureter is not disrupted. The ureter must be separated from the peritoneum with gentle dissection. Once this step has been completed, the Okabayashi space will be exposed. Its limits are the medial leaf of the broad ligament, the ureter laterally, the deep uterine vein anteriorly, and the sacral fascia posteriorly. The deepest part of this space should be the branches of the hypogastric nerve (see Fig. 7.5). The ureter should be dissected distally to the point below the uterine artery to facilitate the dissection of the parametria.

At this point in the operation, the following anatomic landmarks should be identified:
- superior vesical or obliterated umbilical artery
- round ligaments
- uterine artery
- hypogastric artery
- obturator nerve
- hypogastric nerve
- ureter
- ureteral tunnel
- deep uterine vein
- paravesical space
- inner and outer pararectal spaces (Figs. 7.6 and 7.7)

Bladder Dissection
With the assistant placing upward traction on the uterus (if abdominal) or pushing upward with the uterine manipulator (if laparoscopic or robotic), the bladder fold should be identified. The peritoneum overlying the bladder should then be transected and opened, providing exposure to the uterovesical space. With gentle dissection, the bladder may be separated...
from the anterior vaginal wall. The most important part of this step is identification and development of the Yabuki space. The limits of the Yabuki space are the ureter laterally as it enters the bladder; the lateral vaginal wall medially; the bladder anteriorly; and the endocervical fascia and the uterine vessels entering into the uterus at its isthmus, posteriorly. This space is located laterally, below the bladder pillars. Once this space has been opened, one can see the distal part of the ureter entering the bladder (Figs. 7.8 and 7.9).

One should not dissect deeper than this space because the deep uterine vein may be easily injured. This step allows the surgeon to define the anterior vaginal resection margin. If a laparoscopic procedure is being performed, the cup of the uterine manipulator may be seen at this point, and the resection margin can be defined.

**Uterine Artery Ligation and Unroofing of Ureter**

The uterine artery must be ligated at its origin from hypogastric artery. Once this has been done, the uterine artery should be lifted and the dissection below the artery should continue. With medial traction on the uterine vessels, the surgeon must unroof the ureter. If performing a radical hysterectomy by laparoscopy, the surgeon must try to avoid contact between the vessel sealing device and the ureter. Thermal injury to the ureter at this point may lead to development of ureteral fistulas. When the uterine artery and its surrounding tissue are already separated from the ureter, bladder, and vaginal wall, the surgeon can see the ureterovesical junction, and the anterior parametria, which is then ligated (Fig. 7.10).

**Parametrial Resection**

To resect the parametria posteriorly, the surgeon must take care to separate and “lateralize” the hypogastric nerve before transsecting the posterior aspect of the parametria. The hypogastric nerve is located 3 to 4 cm below the ureter, attached to the peritoneum of the posterior leaf of the broad ligament, and it tracks toward the bladder, passing behind and below the deep uterine vein, where together with splanchnic fibers it forms the inferior hypogastric plexus. It is very important to dissect the nerve in all its extension and to maintain it behind the deep uterine vein. Once the nerve has been dissected and isolated, the surgeon can cut the uterosacral ligaments (without including the neural structures). This is done to avoid bladder motility disorders. At this point in the procedure, the uterus is primarily attached to the lateral parametria and paravaginal tissue (paracolpium). When estimating the resection of the parametria, one must remember that the hypogastric nerve is the inferior margin of the resection. At this point, the uterus will be attached only to the vagina, and the surgeon should be sure to resect at least a 2-cm circumferential margin of the upper vagina (Figs. 7.11 and 7.12). The vaginal cuff should be closed with absorbable sutures. If a laparoscopic technique is being performed, the vaginal cuff may be sutured with a running absorbable suture in one or two layers. Some surgeons may prefer to leave the vaginal cuff open to remove the nodal bundle of the pelvic lymphadenectomy through the vagina and subsequently proceed with closure. One should then confirm that both ureters are intact and that the hypogastric nerves are also intact. At this point the specimen should be examined for adequacy of resection (Figs. 7.13–7.15).
Pelvic Node Dissection

Pelvic lymph node status is the strongest predictor of oncologic outcome in patients with a diagnosis of cervical cancer. The overall 5-year survival rate among node-negative patients after radical hysterectomy is approximately 80% to 90%. However, when there is evidence of pelvic lymph node involvement, the survival rate drops significantly to approximately 30% to 60%.$^{17,18}$

To date, the gold standard method to assess pelvic nodal status is comprehensive pelvic lymphadenectomy. However, a recent study by Salvo and colleagues$^{32}$ showed that the false-negative rate of sentinel lymph node mapping in patients with early-stage cervical cancer was 3.6%. This suggests that perhaps routine pelvic lymphadenectomy may not be necessary.

When a pelvic lymphadenectomy is performed, the anatomic boundaries are as follows: proximally, the bifurcation of the iliac vessels; distally, the circumflex iliac vein crossing over the distal iliac artery; laterally, the genitofemoral nerve; and medially, the iliac vessels. The most inferior portion of the dissection is the obturator nerve (Fig. 7.16). One should not use drains after pelvic lymphadenectomy because these have not been shown to decrease the rate of lymphocyst
formation and may, in fact, increase the rate of infectious complications.\textsuperscript{33}

Regarding bladder drainage, Wells and colleagues\textsuperscript{44} published a retrospective analysis including 212 patients who underwent a radical hysterectomy (134 with TUCs vs. 78 with SPCs), comparing the two methods of bladder drainage. The authors found a higher rate of urinary tract infections (27\%) in the TUC group compared with the SPC group (6\%; \textit{P} < .001); a shorter hospital stay favoring the SPC group (4.8 vs. 5.7 days; \textit{P} < .001); and an earlier trial of voiding (2.7 vs. 4.4 days; \textit{P} < .001) in the SPC group. The authors concluded that after a radical hysterectomy, suprapubic catheterization is associated with a lower rate of urinary infections and an earlier successful trial of voiding than transurethral catheterization. In another study, Naik and colleagues\textsuperscript{45} reported a higher incidence of urinary infections in patients who were performing intermittent self-catheterization than in patients with SPCs (42\% and 18\%, respectively). Similarly, Van Nagell and colleagues\textsuperscript{46} described a 44\% rate of urinary tract infections in patients with TUCs compared with a rate of 23\% in patients with SPCs.

**Complications of Radical Hysterectomy**

The overall complication rate after radical hysterectomy ranges from 26.7\% to 50\%.\textsuperscript{37-39} In general, complications are categorized as occurring intraoperatively; occurring less than 30 days after surgery (early); and occurring more than 30 days after surgery (late).

**Intraoperative Complications**

During an open surgical procedure, injury of bladder, bowel, vascular structures, or nerves is a very rare event. The most common intraoperative complication of radical hysterectomy is bleeding. The reported rates of intraoperative blood loss range from 500 to 1500 mL.\textsuperscript{40,41} The majority of blood loss during a radical hysterectomy occurs in general in the dissection of the anterior and lateral parametria. In a meta-analysis comparing three different techniques of radical hysterectomy, including 21 studies (1339 patients) of LRH, 14 studies (1552 patients) of open radical hysterectomy, and 12 studies (327 patients) of RRH, the median percentages of blood transfusion were 25\%, 2.7\%, and 0\% for abdominal, laparoscopic, and robotic approaches, respectively. The rate of blood loss decreased significantly when minimally invasive approaches were used, with a median of 209 mL (range, 143–443 mL) and 133 mL (range, 50–355 mL) for laparoscopic and robotic approaches, respectively.\textsuperscript{19}

**Postoperative Complications**

Among early postoperative complications, the more frequent are related to the urinary tract and its innervation. In general, there is a strong correlation with the amount of parametrial and paravaginal tissue removed during the operation. The reported incidence of lower urinary tract dysfunction after radical hysterectomy varies from 8\% to 80\%.\textsuperscript{42,43} To avoid urinary complications, the surgeon must avoid extensive parametrial or paravaginal resection.

Lower urinary tract dysfunction after radical hysterectomy includes the inability to empty the bladder, dysuria, increased frequency of urination, increased micturition urgency, nocturia, bladder sensory loss, abdominal straining on micturition, urge incontinence, and stress incontinence.\textsuperscript{44,45} Spontaneous recovery of bladder function is typically expected within 6 to 12 months after operation.\textsuperscript{46,47} Vesicovaginal and ureterovaginal fistulas after radical hysterectomy have been reported in 0.9\% to 2.7\% of patients.\textsuperscript{48,49} Among the risk factors for urinary fistula development are stage of the disease, intraoperative bladder injury and hemorrhage, obesity, diabetes, extensive parametrial dissection (particularly after conization or prior radiotherapy), tumor larger than 4 cm, vaginal involvement, and postoperative infections. These factors may affect the rate of devascularization of the ureters, thus leading to a higher risk of fistula formation.

The most common presentation of urinary fistulas is continuous vaginal leakage of urine during the first to fourth postoperative weeks. To rule out a vesicovaginal fistula, one should perform a thorough speculum examination combined with a “tampon test” while infusing methylene blue solution into the bladder. Alternatively, one may perform a cystoscopy to directly assess bladder wall integrity. Early diagnosis of fistulas is essential to reduce delay in treatment and long-term urologic morbidity. Conservative treatment by placement of a bladder catheter for several weeks is one option, because spontaneous closure of a vesicovaginal fistula after continuous bladder drainage occurs in 15\% to 20\% of patients.\textsuperscript{50} Factors contributing to successful conservative management are a short interval between diagnosis and drainage, limited duration of drainage, and small size of the fistula.

If conservative treatment fails, the patient should undergo surgical repair. The success rate of primary closure of the fistula is dependent on the location, size, and vascularization of the surrounding tissues. Both vaginal and abdominal approaches are possible, depending on the location of the fistula. In general, the first attempt at fistula closure is associated with the highest success rate. If primary closure fails, urinary diversion is most likely the only remaining option. In the diagnostic workup of a bladder fistula, the presence of a ureteric fistula should also be ruled out—for example, by using CT with intravenous pyelography. Although a rare event, a ureteric fistula should be treated at the earliest possible time, especially in patients with intraperitoneal leakage. Treatment of ureterovaginal fistulas mostly consists of surgical intervention. Conservative measures such as ureteric stenting and nephrostomy placement can be attempted, but often surgical repair by ureteric reimplantation combined with psoas hitch or Boari flap should be performed.\textsuperscript{50}

Pelvic lymphocyst formation is another postoperative complication than may occur after lymphadenectomy. The reported incidence is 6\% to 22\%.\textsuperscript{51,52} The frequency of lymphocyst may also vary based on the method used for detection of this complication. The incidence may be reported as low if the method of assessment is symptomatic manifestation. However, the frequency may be much higher if one uses more objective measures of evaluation such as imaging studies (pelvic ultrasound or CT scans). Most lymphocysts are asymptomatic and resolve spontaneously within several months after operation. Only a small percentage of patients (1.4\%) require drainage. The standard procedure is ultrasound- or CT-guided percutaneous drainage, as recommended by Conte and colleagues.\textsuperscript{53}

The incidence of urinary tract infections after radical hysterectomy ranges from 11\% to 20\%.\textsuperscript{54,55} This complication may
manifest with vague lower back pain, malaise, fever, and dysuria. When a urinary infection is suspected, one should consider a confirmatory evaluation by performing a urinalysis and urine cultures, particularly if the patient is febrile and has evidence of leukocytosis. The antibiotic regimen should be tailored according to the findings on the urine cultures. To avoid urinary tract infections, one should consider removing the urinary catheter at the earliest possible time.

The most common late complication of radical hysterectomy is lower limb lymphedema. The risk of developing this complication ranges from 5% to 20%. Similar to the rate of lymphocyst formation, the incidence of lymphedema varies according to the method used for detection. Patients with lymphedema after a radical hysterectomy may have significant associated morbidity, including pain, impaired function of the lower extremity, and various psychological, social, and quality-of-life issues. Lower extremity lymphedema (LEL) developed within 1 year of operation in 47 (60.3%) patients and occurred in 64 (82.1%) within 3 years of lymphadenectomy. The cumulative incidence of LEL at 1, 3, 5, and 10 years was 12.9%, 17.3%, 20.3%, and 25.4%, respectively. Kaplan-Meier analysis showed a significantly higher frequency of cumulative LEL in patients with a closed retroperitoneum than in those with an open retroperitoneum (P < .0001), in patients with removal of circumflex iliac nodes than in those with preservation of circumflex iliac nodes (P < .0001), in patients with cellulitis than in those without cellulitis (P < .0001), in patients with fewer than 70 lymph nodes removed than in those with 70 or more lymph nodes removed (P = .020), and in patients with lymph node metastasis than in those without lymph node metastasis.

Once lymphedema has been diagnosed, compression stockings and physical therapy are commonly used, with a success rate up to 92%. As a preventive measure, a recent study suggested that one should avoid pelvic lymph node dissection distal to the circumflex iliac vein, in the ganglionic group called CINDEIN (circumflex iliac nodes distal to external iliac nodes). The authors of these studies have proposed that the removal of these lymph nodes markedly increases the possibility of development of lymphedema, especially if adjuvant radiotherapy is used.

The standard implementation of sentinel node dissection techniques will hopefully reduce the incidence of LEL. Lymphovenous anastomosis has been proposed as a treatment option in patients in whom medical or conservative treatment has failed. Mihara and colleagues published a retrospective analysis including 84 patients (162 limbs; 73 female and 11 male patients) with lower limb lymphedema who underwent multistage lymphaticovenous anastomosis. The average age was 60 years (range, 24 to 94 years); mean postoperative follow-up period was 18.3 months (range, 6 to 51 months). The postoperative change rate in limb circumference indicated that 67 limbs (48%) were classified as improved, 35 (27.3%) were classified as stable, and 32 (25%) were classified as worse. Postoperative interview revealed improvement in subjective symptoms in 67 limbs (61.5%), no change in 38 (35%), and exacerbation in four (3.7%). The postoperative mean occurrence of cellulitis decreased to 0.13 times per year compared with 0.89 preoperatively (P = .00084). The authors concluded that lymphaticovenous anastomosis is effective for lower limb lymphedema in point of limb circumference, subjective symptoms, and the frequency of cellulitis.

### Summary

ARH remains the preferred approach for most patients with early-stage cervical cancer, given the lack of minimally invasive technology in the developing world, where cervical cancer is most prevalent. It is important to ensure that all patients undergo appropriate preoperative evaluation and that patient selection is optimal in order to achieve the best possible outcomes. In performing the procedure, it is critical to ensure that adequate anatomic exposure is achieved and that all key steps of the procedure are appropriately followed. Given modern approaches in perioperative care, radical hysterectomy is currently associated with low morbidity and mortality. Further research will explore whether less aggressive procedures will be performed in the future and whether sentinel lymph node mapping alone will become the new standard of care.

### Key Points

- Radical hysterectomy is generally recommended in the setting of stage IA2 to IIA1 cervical cancer.
- Routine preoperative workup includes a chest radiograph. Pelvic imaging with CT, MRI, or PET-CT is recommended only in the setting of high-risk factors for metastatic disease.
- Extent of the dissection is based on tumor size and stage.
- Indications for adjuvant therapy include positive pelvic nodes, vaginal or parametrial margins involved with disease, deep stromal invasion (>1/3), or ovarian metastasis.
- Approximately 15% to 20% of patients require postoperative chemotherapy and radiation after radical hysterectomy.
- Minimally invasive approaches are superior when compared with open approaches, because the former are associated with decreased postoperative pain, blood loss, transfusion rates, and length of stay.
- The most common intraoperative complication of open radical hysterectomy is blood loss.
- The most common postoperative complication after open radical hysterectomy is lower urinary tract dysfunction.
- The 5-year overall survival rate of radical hysterectomy without risk factors for adjuvant therapy exceeds 90%.
- Sentinel node mapping is becoming increasingly more popular and ultimately may replace complete lymphadenectomy.

### References


Along with ovarian cancer debulking and radical hysterectomy, pelvic and paraaortic lymph node dissections are procedures that define gynecologic oncology. Complete pelvic and paraaortic lymphadenectomies (open and transperitoneal) for staging in early-stage cervical cancer are similar in approach to procedures for uterine cancer (see Chapter 9 for details). Lymphatic mapping and sentinel lymph node biopsy for early-stage cervical cancer are also described elsewhere in this book (see Chapter 6). This chapter focuses on the rationale for and approach to surgical staging in locally advanced cervical cancer (stages IB2–IVA).

The limitations of the clinical staging system in detecting nodal disease in patients with cervical cancer have led many practitioners to augment their clinical examinations with imaging such as computed tomography (CT), magnetic resonance imaging (MRI), and/or positron emission tomography (PET). Knowledge of status of nodal basins in the pelvis and abdomen is important for both prognostic and therapeutic reasons. First, the presence of positive lymph nodes remains the most important adverse prognostic factor for survival in patients with cervical cancer. Furthermore, the presence or absence of metastases in the lymph nodes guides treatment planning. This may include the choice of primary surgery or radiotherapy as well as determination of the radiation field size—pelvic versus extended field.

Unfortunately, none of the imaging modalities currently available has proven to be particularly sensitive in detecting metastases in paraaortic lymph nodes in patients with locally advanced cervical cancer (stages IB2–IVA). CT has a sensitivity of only 67%, and although MRI may perform well in the detection of parametrial, bladder, and rectal invasion from primary cervical tumors, it performs poorly in the detection of lymph node metastasis. In a meta-analysis of MRI for the detection of lymph node metastasis, Scheidler and colleagues reported an overall sensitivity of MRI of 38%. Other authors have found that MRI had a sensitivity of 0% in the detection of positive paraaortic lymph nodes when compared with surgery and pathologic evaluation.

In many centers, fluorodeoxyglucose (FDG)-PET is used as the best means to detect nodal spread in women with cervical cancer. When compared with the gold standard of surgical staging, FDG-PET has a sensitivity of 84% (95% confidence interval [CI], 68%–94%) in detecting metastatic disease to regional lymph nodes. Unfortunately, that low sensitivity means that 16% of women will be incorrectly categorized as having node-negative disease when the regional lymph nodes actually are harboring disease. The implications of undertreating these patients may be disastrous, given that the survival rate for patients with histologically positive paraaortic lymph nodes treated with extended-field radiation therapy is as high as 50%.

As many as 25% of women with locally advanced cervical cancer (stages IB2–IVA) will have metastatic disease to the paraaortic nodes. Two studies evaluated the sensitivity of FDG-PET/CT in the detection of pathologically positive paraaortic nodes. Both of these studies compared the findings of FDG-PET/CT versus examination of paraaortic lymph nodes surgically resected via a laparoscopic extraperitoneal approach in women with locally advanced cervical cancer (stages IB2–IVA). For women with PET-CT scans showing probable metastases in pelvic nodes and disease-free paraaortic nodes, 21% to 24% were found to have positive paraaortic nodes on standard hematoxylin-and-eosin (H&E) pathologic review of the surgical specimen. Furthermore, when ultrastaging and immunohistochemistry were performed on nodes thought negative after standard H&E pathologic processing, another 2% to 8% of patients had additional micrometastatic disease in these lymph nodes. Had treatment planning been based solely on the best available imaging (PET-CT), a significant number of women with paraaortic metastases would have been undertreated with pelvic irradiation only, when in reality extended-field irradiation was required.

For women with locally advanced cervical cancer, a pretreatment paraaortic lymph node dissection may also provide real therapeutic benefit in addition to the important prognostic and therapy-directing information gleaned through the surgical procedure and pathologic assessment of lymph nodes. Multiple studies have shown that patients with microscopically positive paraaortic lymph nodes that were resected laparoscopically had the same survival rate as patients with pathologically negative paraaortic lymph nodes on surgical staging. Although it is...
commonly accepted that FDG-PET/CT performs poorly in the detection of microscopic disease spread to the paraaortic nodes in women with locally advanced cervical cancer, it is not known whether surgical staging improves outcomes for these patients.

Traditionally, paraaortic node dissection was performed only through a large vertical midline incision. In the early 1990s, however, the laparoscopic transperitoneal approach was pioneered in the United States and France. The adoption of the laparoscopic approach greatly decreased the morbidity of the paraaortic node dissection, with major complications encountered in less than 2% of procedures.

In the late 1990s, the laparoscopic extraperitoneal approach was developed. This approach improved visualization in obese patients and reduced the morbidity associated with adjuvant radiation in women with locally advanced cervical cancer. In addition, lymph node counts were higher with the extraperitoneal approach compared with transperitoneal or open paraaortic lymphadenectomies.

This chapter describes the laparoscopic extraperitoneal lymph node dissection for surgical staging in women with locally advanced cervical cancer. This approach can be easily adopted to robotic and single-incision platforms.

Anatomic Considerations

Lymphatic nodes and vessels cover the inferior vena cava (IVC) and aorta circumferentially. For gynecologic malignancies, the nodes anterior and lateral to the great vessels are those at risk, although, uncommonly, nodes posterior to the vessels may be involved. This is in contrast to urologic cancers, in which the posterior nodes are at high risk and commonly removed as part of the standard lymphadenectomy. The lower portion of the aorta and vena cava (below the inferior mesenteric artery) receive lymphatic fluid and debris from the common iliac nodes, whereas the nodal basins above the inferior mesenteric artery receive lymphatic fluid and debris from the lower aortocaval lymphatics and are at the terminal end of the basins draining the uterine fundus and ovaries along the gonadal vessels (Fig. 8.1). Lymph fluid and debris from the liver, spleen, stomach, and bowel flow into lymphatics around their respective pedicles and collect into celiac and mesenteric nodes, located around the origins of their respective preaortic arteries. The aortocaval nodal basins between the inferior mesenteric artery and renal vessels also coalesce with the mesenteric and celiac basins. From these nodes, efferent lymphatics gather to form intestinal lymphatic trunks and form the basis for the thoracic duct, which transports lymph from the abdomen and the intercostal spaces into the general venous circulation, through the left (preferentially) or right subclavicular vein or both. The inferior part of the thoracic duct arises from the convergence of these big collectors located at the level of the L1–L2 vertebrae, between the aorta and the right diaphragmatic pillar. In a small proportion of people, this area forms a sacciform expansion called the cisterna chyli (or Pecquet cisterna). It collects lymph from the whole abdomen, the diaphragm, and the last intercostal spaces before forming the thoracic duct. The size and shape of this cisterna are highly variable.

The transperitoneal approach to the paraaortic nodes requires mobilization of portions of the duodenum, pancreas, and the right colon in order to adequately expose IVC and aorta from the left renal pedicle to the common iliac bifurcations caudally. A standard gynecologic template requires removal of the precaival and lateral (right-sided) nodal basins, inter-aortocaval nodes, and preaortic and lateral (left-sided) nodes. Nodal basins lateral to the aorta and between the aorta and vena cava (inter-aortocaval) are mixed with the postganglionic nerve fibers that arise from the vertebral sympathetic chains. In addition, the lateral and inter-aortocaval nodes are in close relationships with the lumbar pedicles, a possible source of significant bleeding. In rare cases in which disease is detected behind the aorta and vena cava, some lumbar vessels have to be divided to access the retro-aortocaval region (a maneuver called the “split-and-roll” technique by urologists). Above the renal pedicle, the superior mesenteric and celiac nodes are more challenging to approach. However, they are rarely involved in gynecologic diseases; therefore a systematic dissection to this level is not justified as a routine practice.

Of importance during a lymphadenectomy, lymphatic channels are especially large around both common iliac pedicles and the left renal pedicle, especially in the inter-aortocaval space, and laterally to the aorta. Careful division and ligation of these channels to obtain lymphostasis are important in these areas to prevent the secondary development of lymphocysts or chylous ascites. Suture, clips, or advanced vessel sealing devices can be used.

General Instrumentation

Whatever the approach, a laparoscopic paraaortic lymph node dissection does not require sophisticated instruments. Most procedures can be done with a 0-degree or 30-degree laparoscope, two fenestrated grasping forceps, scissors, bipolar forceps, an irrigation-suction device, and endoscopic bags. Advanced vessel sealing devices are useful if available but are not required for the procedure to be safely performed. However, good knowledge
of their functioning and limits is mandatory to avoid vascular or nervous damage. Finally, a set of instruments for laparotomy along with some instruments for vascular surgical procedures must be always available in the operating room in case of bleeding that cannot be safely controlled laparoscopically.

For the transperitoneal approach, most surgeons will use three or four trocars (see Chapter 25 for details). For the extraperitoneal approach, three trocars are typically used: a 10-mm balloon trocar for the camera, a 10- to 12-mm operative port, and a 5-mm operative port. Occasionally a fourth 5-mm trocar is necessary.

### Extraperitoneal Laparoscopic Paraaortic Node Dissection

#### Patient and Staff Positioning

Because most nodal basins at risk are located lateral to the aorta, a left internal iliac approach is favored in the absence of obvious right-sided involvement. After general anesthesia has been obtained, a nasogastric tube and a Foley catheter are placed. The patient is positioned supine on the operating room table with a slight curve made by the hips and shoulders as the abdomen is set along the left table edge. The left arm may be positioned “out” at 90 degrees; the right arm may be tucked along the trunk (Fig. 8.2). Slight Trendelenburg and right-sided table tilt are helpful in exposing the retroperitoneal structures, especially in overweight patients. After intraperitoneal exploration (see later), both surgeon and assistant will stand on the patient’s left side, with the monitor positioned across the table on the patient’s right side.

#### Technical Description

The operation starts with diagnostic laparoscopy to rule out carcinomatosis or evidence of intraabdominal metastasis. For this purpose, an umbilical trocar for the camera and a 5-mm trocar for an instrument in the right iliac fossa are necessary.

#### Entry Into Extraperitoneal Space and Placement of Trocars

Entry into the left iliac extraperitoneal space is obtained by either of two methods. The first approach is under direct visualization. A 2-cm skin incision is performed three fingerbreadths above the anterior iliac spine and one fingerbreadth medial to the iliac crest (Fig. 8.3). The fibers of the three muscular layers of the external oblique abdominal muscle, internal oblique abdominal muscle, and transverse abdominal muscle are gently separated with blunt surgical clamps or by use of a spreading motion with surgical scissors. This dissection should be performed in the direction of the fibers to split the muscle without causing bleeding. After splitting of the muscle fibers of the transverse abdominal muscle, the peritoneum should be visible (Fig. 8.4). Another technique for obtaining access to the retroperitoneal space consists of a blunt approach after incision of the skin in the iliac fossa. This is followed by penetration of the surgeon’s forefinger bluntly through the three layers of abdominal wall muscles, under the visual control of the intraperitoneal camera in the umbilicus.

At this point the surgeon’s left forefinger is introduced into the extraperitoneal space to delicately detach the peritoneum from the medial aspect of the transverse abdominal muscle laterally, the quadratus lumborum, and the psoas muscle posteriorly (Fig. 8.5). Under finger control, a 10- to 12-mm trocar is introduced into the flank (on the midaxillary line) posteriorly (Fig. 8.6). Once this trocar has been placed in the extraperitoneal space, CO₂ inflation is obtained to a pressure of 12 mm Hg. Careful placement of trocars so as not to injure or rupture the peritoneum is key for obtaining insufflation of the retroperitoneal space and with it the visualization necessary to perform the procedure. The laparoscope is introduced through this port to control the extraperitoneal space and to place the second 5-mm operative trocar under the costal margin.
(midclavicular line) through the transverse muscle after the peritoneum has been detached and moved away with the finger (Fig. 8.7). The incision used for the finger to assist with placement of the other two trocars is replaced by a 10- to 12-mm balloon trocar placed with direct visualization (Fig. 8.8). The camera is placed in this iliac trocar and the instruments in the other two trocars. The lymphadenectomy can then be started.

**Development of Extraperitoneal Space**

Development of the extraperitoneal space begins with elevation of the peritoneum from the psoas muscle laterally and cranially to the level of renal pedicle. The left ureter and infundibulopelvic ligament remain attached to the peritoneum and are elevated above the field of dissection.

**Mobilization of Nodal Tissue Along the Lateral Portions of the Left Common Iliac Artery and Aorta**

The extraperitoneal laparoscopic paraaortic lymph node dissection separates all of the lymphatic tissue from the great vessels; it is left attached to the peritoneum above it. Once this is completed, the lymphatic tissue is separated from the intact posterior peritoneum and duodenum. Proceeding in this manner minimizes the risk of tearing the peritoneum and losing the ability to keep the pneumoperitoneum in the retroperitoneal space, which is necessary for visualization. The pressure of CO₂ gas should not exceed 15 mm Hg.

Node dissection starts with the mobilization of the nodal basins along the lateral portions of the left common iliac artery and aorta. The anterior aspect of the left common iliac artery is cleared from nodes from the crossing with the ureter caudally (level of the common iliac bifurcation) up to the left hypogastric nerve, which crosses the aorta and its bifurcation (Fig. 8.9). This nerve is followed laterally to identify the inferior postganglionic fiber arising from the left sympathetic chain. This fiber is anatomically important as a means to identify the inferior mesenteric artery as it crosses at its origin. In retracting this fiber from the aorta, the inferior mesenteric artery is identified, and after identification of the inferior mesenteric artery the fiber can be sacrificed (Fig. 8.10). The dissection proceeds superiorly as nodal tissue is freed from the lateral aspect of the aorta. The origin of the left gonadal artery should be identified next and should be differentiated from a renal polar artery. One way to differentiate these two vessels is to remember that the gonadal artery does not move when the left gonadal vein, found at the most superior portion of the extraperitoneal space, is mobilized. Once identified, the left gonadal artery should be desiccated and divided.
The upper border of the extraperitoneal paraaortic lymph node dissection is the left renal vein. This major vessel can be found by following the left gonadal vein, still attached to the peritoneum forming the ceiling of the space, as it flows into the left renal vein. At the level where the left gonadal vein joins the left renal vein, one can often find the azygolumbar vein, also known as the hemiazygous vein, draining into the left renal vein, from the floor of the dissection. The azygolumbar vein is formed by the 12th intercostal vein and ascending lumbar vein.

The nodes dissected from the lateral portions of the common iliac artery and aorta are then elevated from the posterior structures (sympathetic nerve chains and vertebral plane). Care must be taken not to damage the nervous chain (limb sympathetic syndrome) or the lumbar vessels. These vessels are located directly on the vertebral plane and are crossed anteriorly by the sympathetic chain. Following the anterior aspect of the sympathetic chain will facilitate their identification and preservation.

Near the renal vein there is commonly a large lymphatic collector that must be clipped to prevent significant lymphatic fluid collection and possible formation of chylous ascites. The nodes from the lateral portion of the superior aorta are detached from the renal pedicle. At this point, the left renal artery and a possible lymphoazygos anastomosis must be identified, with care taken not to cause damage.

**Mobilization of Nodal Tissue Along the Anterior Portion of the Aorta and Vena Cava**

The next step is mobilization of the nodes along the anterior portion of the aorta and between the aorta and vena cava (inter-aortocaval nodes). The anterior aspect of the left renal vein is cleared, and the preaortic nodes are elevated from the renal vein cranially to the origin of the inferior mesenteric
artery caudally. The inter-aortocaval nodes are then mobilized. The use of clips or advanced sealing devices will prevent small-volume bleeding during this step. While these nodes are being mobilized, the origin of the right gonadal artery will become visible, and it should be immediately desiccated and divided. The anterior aspect of the vena cava is identified. It can be followed cranially to the insertion of the left renal vein and caudally to the level of the inferior mesenteric artery. Pre-caval nodes are carefully elevated from the IVC. Any vessel going into a node must be preventively desiccated and cautiously divided to prevent a possibly life-threatening hemorrhage. When dissection above the inferior mesenteric artery is completed, the dissection below the inferior mesenteric artery dissection is started.

The inframesenteric dissection is the last step of the procedure. Once the aortic bifurcation is cleared, the left common iliac vein is carefully identified below the promontory. Following the right common iliac artery, the right ureter is identified and elevated and the dissection proceeds to the level of the right common iliac bifurcation. The nodal basins are separated from the artery until the psoas muscle is visible. Then preaortic nodes below the inferior mesenteric artery are elevated until the right hypogastric nerve is visible. The inferior part of the vena cava is just behind this nerve. After this nerve is divided, the anterior aspect IVC is progressively cleared from nodes, with particular care paid to the “fellow’s vein” frequently found at this level.

Removal of Detached Nodal Bundles
The nodal tissue separated from the lateral portions of the left common iliac artery and aorta, the anterior aorta and vena cava, and between the aorta and vena cava are then detached from the posterior peritoneum. Starting at the renal vein, the nodes are separated from the duodenopancreas and the lymphatic channels are carefully clipped and divided to reduce accumulation of lymph and possible formation of chylous ascites. The nodal tissue is separated from the posterior peritoneum by simply sweeping down to common iliac bifurcations. The nodes, stored laterally to the psoas, are placed in a bag and extracted through the iliac port site. After replacement of the balloon trocar, lymphohemostasis is carefully checked and completed if required.

“Preventive Marsupialization” and Completion of the Procedure
To prevent lymphocyst formation, a large fenestration in the left paracolic gutter is created (“preventive marsupialization”). Although feasibly achieved via the extraperitoneal space (taking care not to open the sigmoid colon), it is more easily and safely performed transperitoneally after re-insufflation of the pneumoperitoneum. A 10-cm incision, away from the iliac trocar, is recommended. Placement of intraperitoneal or extraperitoneal drains is not necessary. All trocars are removed and incisions carefully closed. For uncomplicated procedures, patients are typically discharged on the same day as the operation or on the first postoperative day.

Additional Considerations
Complete Inter-aortocaval Dissection
Mobilization of inter-aortocaval nodes by means of the extraperitoneal approach is not easy, especially with an anterior approach. Typically, only the superficial nodes are removed. If a thorough resection is required, the aorta must be mobilized to the vertebral plane. Lumbar arteries are isolated, clipped, and divided. It is interesting to note that the lumbar arteries are always paired: If a left one is encountered, the right one is just opposite. Division of lumbar veins is not necessary. Care should be taken not to injure the Adamkiewicz artery (AKA), which results in a definitive paraplegia. Injury to this artery should be prevented by preservation of the upper pair of lumbar arteries, caudal to the renal pedicle, as the AKA arises from branches of T11–L1 lumbar arteries. The risk of encountering the AKA at this level (L2) is less than 2%.

After two or three pairs of lumbar arteries have been divided, the aorta can be elevated, giving access to the deep inter-aortocaval nodes (Fig. 8.11). These nodes are detached from the prevertebral plane and retrieved directly or from the anterior part of this space.

Through this approach, the vena cava can also be elevated from the vertebral plane to collect retrocaval nodes. If resection of these nodes is necessary, a contralateral right-sided extraperitoneal dissection may be preferred.

Great care must be taken during these maneuvers because injury to the vessels could cause a potentially life-threatening hemorrhage. In addition, this procedure should be carefully considered in older or atherosclerotic patients because they are at risk of atherosclerotic thrombosis, embolization, or both.

Gonadal Pedicle Resection
Removal of the gonadal vessels may be desired, particularly if the nodal dissection is for ovarian cancer staging. The gonadal veins are most easily identified at their junction with the vena cava or the left renal vein. They can be divided at this level. The respective arteries, already divided during the paraaortic dissection, usually run just next to the veins. Then gonadal pedicles are followed to their crossing with ureters, from which they must be clearly differentiated and separated. They can be divided caudally, close to the common iliac pedicles.

Nerve-Sparing Dissection
Three pairs of postganglionic sympathetic fibers can be found in the template during the extraperitoneal paraaortic node dissection: on the left side arising lateral to aorta and on the right side arising from the inter-aortocaval space (Fig. 8.12). Nerve preservation is necessary to prevent retrograde ejaculation in men. The advantages of sparing these nerves in women is unclear, but their sacrifice may be responsible for some degree of constipation.

Technical Difficulties
Fixed Nodes
The presence of a fixed node and the associated risk of damage to the great vessels remain a challenging situation for the laparoscopic approach. Although vascular wall involvement is a late step in disease evolution, it is not unusual to find a diminished surgical plane between the enlarged node and vessel. When this situation is anticipated at preoperative imaging, the extraperitoneal approach offers the advantage of a lateral view of the plane and may be more adapted to deal with this difficult dissection.
However, in addition to tumor size, node frailty must also be considered, to avoid spilling tumor cells out into the operative field. If safety conditions cannot be all fulfilled, an open approach (preferably extraperitoneal) should be considered. In addition, if an obvious involved node is removed through an extraperitoneal approach, the preventive peritoneal marsupialization should be avoided, to prevent abdominal cavity contamination.

**Intraoperative and Postoperative Complications**

**Lymphatic Complications**

Thorough control of lymphatic channels is necessary throughout the procedure. However, in spite of good technique (desiccation, sealing, clips), lymphatic fluid accumulation may occur, especially after thorough dissections in the interaortocaval space, or from perirenal or high aortic lymphatics. The additional placement of hemostatic foam may stop it. Management will depend on the amount and severity of accumulation and can range from observation to one-time or repeated drainage. In the event of symptomatic chylous ascites accumulation, high-protein, low-fat diets with medium-chain triglycerides may be recommended. If the condition is recurrent, octreotide injections may help reduce volume of chylous ascites.

Development of lymphocyst seems more frequent with the extraperitoneal approach. Although preventive “marsupialization” has decreased its incidence, it has not been eliminated. Only symptomatic lymphocysts (pain, fever, venous or ureter compression) must be treated. Single drainage with use of imaging guidance may result in a recurrence rate of 60%. Placement of an external drain is the most effective method. To reduce the risk of recurrence, some advocate the instillation of povidone iodine or alcohol in the cyst in an effort to sclerose, although reported results vary widely. In case of failure or infection, surgical drainage or, exceptionally, the ligature of the leaking channel if identified should be considered.

**Lower Extremity Lymphedema**

Lower extremity lymphedema is a rare complication after paraaortic node dissection, although its incidence increases if it is associated with a pelvic dissection or radiation therapy. Education, physiotherapy, and use of compression stockings are the usual components of treatment.

**Hemorrhage**

Bleeding is the most frequent complication encountered and can be a result of direct vascular injury or tearing from poor tissue handling or exuberant retraction. Management will depend on the importance of the vascular structure and the degree of hemorrhage. Although some caval injuries can be controlled laparoscopically, aortic injuries usually necessitate an immediate conversion to laparotomy for efficient and safe repair. Whatever the situation, blind application of electrosurgical cautery, instruments, or clips should be avoided to prevent worsening of the vascular damage. The initial and safest method of hemostatic control should be direct pressure with surrounding tissue or gauze pads to temporarily control blood loss and allow time to prepare for management of the hemorrhage. (See Chapter 22 on control of bleeding.) After correct visualization and instrumentation have been achieved, compression may be gently released. Often, bleeding has stopped at this point from direct pressure alone. If the bleeding remains significant, however, the decision to convert to laparotomy should
not be delayed while applying compression on the bleeding area again. If bleeding has decreased and is thought to be manageable with laparoscopic techniques, hemostasis may be achieved with clips, bipolar coagulation, hemostatic agents, or even suture.

**Bowel Injury and Ureteral Injuries**

Control of all instruments must be a constant preoccupation for the surgeon. If a bowel injury is observed during the procedure, the bowel must be thoroughly inspected, because injury can perforate both sides of the bowel. (See Chapter 18 for management of bowel injuries.) Usually, a single or two-layer suture will fix the damage. Bowel resection or need for an ostomy is rare. Postoperatively, attention must be paid to any abnormal course, especially the association of fever, abdominal pain, or inflammatory processes.

Injury to the ureter can occur during node dissection, especially of fixed nodes. Intravenous injection of blue dyes may be helpful in the diagnosis of a ureteral injury. (See Chapter 19 for management of urologic injuries.) Rarely, secondary ureteral necrosis can occur after pelvic and paraaortic lymphadenectomies. These can occur days or even weeks after operation. Finally, ureteral stenosis may occur after difficult dissections, and if the stenosis is symptomatic, the endoscopic placement of stents may be indicated.

**Anatomic Variations**

Thirty percent of patients will have at least one anatomic variation. This reinforces the importance of checking preoperative imaging and not dividing any vessel before it is clearly identified.

**Renal Artery and Vein Anomalies**

Most of the time, the origins of both renal arteries are located above or behind the left renal vein. As for any rule, exceptions are not rare, and damage can occur in case of a mistake with a lymph node. Any pulsation at a supposed lymph node under the left renal vein should be suspected to be a renal artery, and a careful dissection is mandatory to confirm or rule out the presence of a lymph node at this level.

The most frequent variant of the renal vessels is the presence of renal polar arteries. Although this is more frequently seen on the left side (Fig. 8.13), a right polar artery is possible. There may be difficulty distinguishing a renal polar from a gonadal artery. The renal polar vessel will typically have a larger caliber than a gonadal vessel. If there is any doubt as to which vessel it may be, the vessel should be followed to its origin. The renal polar vessel will lead to the kidney, whereas the gonadal vessels will lead to the vena cava (right gonadal vein), the left renal vein (left gonadal vein), or the aorta (bilateral gonadal arteries). In addition, mobilization of the gonadal vein will help in the identification of the gonadal artery because they run together for most of their route.

The presence of a retroaortic left renal vein (Fig. 8.14) should be recognized preoperatively by checking the preoperative imaging. Following the course of the left gonadal vein will permit identification of the left renal vein.

**Congenital Anomalies of Inferior Vena Cava**

Surgeons will rarely encounter anomalies of the IVC. A left-sided cava may be seen in less than 1% of patients. When this occurs, the left renal vein is typically quite short, and the left
Different devices are available to enable this procedure. Somerville, New Jersey) and GelPOINT

First, the suspension of a especially for a paraaortic dissection. If a lateral para

Because the laparoscopic extraperitoneal

direct access to vessels and nodes.

extraperitoneal approach may be more appropriate for

Potential Limitations

Ureter Variations

Ureter Variations

FIG. 8.14 Retroaortic left renal vein; the left renal vein (A) can clearly be seen coursing posterior to the aorta (B). (From Endean E, Maley B. Embryology. In: Cronenwett JL, Johnston KW: Rutherford’s Vascular Surgery. 8th ed. Philadelphia: Saunders; 2014.)

gonadal vein flows directly into the vena cava as opposed to into the left renal vein. When a left-sided vena cava is encountered, the surgeon should check for the presence of a rightsided vena cava also. If present, the two vena cavae usually join high on the anterior part of the aorta, often at the level of a regular preaortic left renal vein. If caval duplication is complete, the common iliac veins follow their ipsilateral arteries, and consequently there will be no vein below the aortic bifurcation.

Variations in the urinary system, such as duplications, are not infrequent. These anatomic anomalies should be recognized on preoperative images, and surgical planning should then account for them. Because the laparoscopic extraperitoneal paraaortic lymph node dissection keeps the ureters attached to the posterior peritoneum, they are at low risk of injury. A horseshoe kidney is a very rare but challenging anatomic disorder, especially for a paraaortic dissection. If a lateral paraaortic dissection is required, a right-sided approach may be required.

Potential Limitations

Prior retroperitoneal surgical procedures will make further retroperitoneal dissection difficult. Prior operations on the adrenal glands, kidneys, or left colon are not a definite contraindication, and a careful attempt at the procedure may be undertaken. A history of aortoiliac surgical procedures, renal grafting, or extraperitoneal mesh placement for herniation are absolute contraindications for the extraperitoneal approach.

Morbid obesity may be a limiting factor for a laparoscopic transperitoneal paraaortic node dissection. However, the extraperitoneal approach may be more appropriate for obese patients because it avoids prolonged pneumoperitoneum and steep Trendelenburg position and provides more direct access to vessels and nodes. Furthermore, retraction of the small bowel is not a concern in the extraperitoneal approach.

Like obesity, age is not itself a contraindication to the procedure. That being said, the association of age with other comorbidities may represent the true limiting factor. If extraperitoneal paraaortic lymph node dissection is undertaken, mobilization of arteries should be carefully performed to avoid endovascular complications.

The extraperitoneal paraaortic lymph node dissection always begins with a transperitoneal exploration. If the procedure is being performed for surgical staging for locally advanced cervical cancer and carcinomatosis is encountered, the procedure should be immediately aborted in favor of palliative chemotherapy. If the procedure is being performed for other purposes, the surgeon’s clinical judgment should determine if the procedure should continue, although there are very few instances in which it should.

Alternative Approaches

Single-Port Extraperitoneal Approach

It is possible to perform this operation by means of a single-port approach. Different devices are available to enable this procedure. The SILS (Ethicon, Somerville, New Jersey) and GelPOINT (Applied Medical, Rancho Santa Margarita, California) systems have been tried. Significant experience in laparoscopic surgery is mandatory to master this approach, which is really challenging, especially when dissecting the right side.

Robotic Extraperitoneal Approach

Initial experience with robotically assisted laparoscopic extraperitoneal paraaortic lymph node dissection was first reported by Diaz-Feijoo and was retrospectively compared with laparoscopic extraperitoneal paraaortic lymph node dissections performed by the same team. The robotic approach provided a higher node count with lower blood loss with no difference in perioperative morbidity. Narducci and colleagues published the findings from the French preliminary experience and confirmed the feasibility of the procedure with few complications, except for postoperative lymphocysts.

Other Considerations

Surgical Radioprotection in Locally Advanced Cervix Cancer

Locally advanced cervical cancer is typically managed by pelvic or extended-field chemoradiation. The risk of radiation-induced bowel damage is high, and this complication is unfortunately irreversible. In the future the rate of this complication may decrease, thanks to the use of conformal irradiation techniques. Meanwhile, some simple techniques may prevent these complications. First, the suspension of a long sigmoid loop in the left paracolic gutter by one or two stitches by using the epiploic appendices may decrease the risk for stenosis. Similarly, the interposition between the rectum and uterus of an omental J-flap, harvested from the right and transverse colon, may prevent the small bowel from falling into the Douglas cul-de-sac and increase the distance between the anterior aspect of the rectum and the enlarged cervix, thus reducing dramatically the risk of radiation rectitis or enteritis.

Revision of the Patterns of Dissection

Another way to reduce operative time or complications is to reduce the template of the dissection. A complete dissection up to the left
renal vein may be required for the staging of endometrial or ovarian carcinomas, but this is debatable in cervical cancer. A prospective multicenter study confirmed that the rate of skip metastasis above the inferior mesenteric artery is extremely low in locally advanced cervical cancer when inframesenteric nodes are negative, justifying limiting the dissection for this indication from the bilateral common iliac bifurcations caudally up to the origin of IMA cranially.55

**Revision of Indications of Paraaortic Lymph Node Dissection**

As required by the International Federation of Gynecology and Obstetrics (FIGO) staging system, in all cases of ovarian carcinoma, dissection should be performed from the pelvic to the infrarenal paraaortic level, including inter-aortocaval dissection.56 However, mucinous cancer may be an exception, especially the expansile subtype.57 The therapeutic impact of thorough staging including node dissections seems clear in early-stage disease.58 Similarly, in early endometrial carcinomas, usually managed with the laparoscopic approach, all type 2 and intermediate- to high-risk type 1 tumors should remain an indication for a complete ilioinfrarenal staging59 as highlighted by a recent randomized study.60

In cervical cancer, the use of paraaortic lymph node dissection is accepted in the case of positive pelvic nodes to tailor the radiation field; however, it remains controversial when imaging shows no evidence of pelvic or paraaortic adenopathy in locally advanced cervical cancer because the advantage in survival remains uncertain.16,41,42 Some ongoing randomized trials are attempting to clarify the indication.43

**References**


The mainstay of treatment in patients affected by endometrial cancer is surgery, including simple hysterectomy and bilateral salpingo-oophorectomy with or without lymphadenectomy. Regardless of the stage of disease, removal of the uterus is recommended in every patient unless there are medical or surgical contraindications or fertility is to be preserved. Effective surgical treatment for early-stage endometrial cancer can be achieved through several approaches, all with comparable outcomes. These include open surgery, laparoscopy, and robotic surgery. Vaginal hysterectomy with bilateral salpingo-oophorectomy has been extensively described as a possible minimally invasive alternative; however, the inability to adequately explore the retroperitoneum intraoperatively has traditionally limited its use to very select cases.

Multiple studies have shown that a minimally invasive approach is associated with less perioperative morbidity and improved postoperative quality of life compared with open procedures, mainly in the short-term period. There is also evidence that laparoscopic surgery has no adverse effect in terms of disease-free and overall survival. Unfortunately, it must be recognized that common clinical practice is far removed from the recommendations provided in the medical literature, and patients treated with minimally invasive procedures represent only a small percentage of all women who undergo surgery for endometrial cancer in the United States and all over the world. The adaptation of laparoscopic techniques has been hindered by challenges such as the need for long-term dedicated training before technically difficult procedures such as endometrial cancer staging can be accomplished. More recently, the introduction of robotic surgery has facilitated the transition from traditional open surgery to a minimally invasive approach and has allowed more surgeons and institutions to move toward endoscopic treatment of uterine malignancies.

Evidence regarding the optimal surgical approach for endometrial cancer patients with multiple medical comorbidities is scarce, and obesity and older age have long been considered contraindications to minimally invasive procedures. However, recent data support the contrary. A recent Italian multicenter cooperative study on obese women with endometrial cancer has shown that, although operating on an obese patient may present a surgical challenge, a laparoscopic approach provides multiple advantages over open surgery, even in the setting of morbid obesity. The same group investigated the role of laparoscopic surgery in elderly women diagnosed with endometrial cancer. A detailed age-stratified analysis was conducted on a cohort of more than 1600 women. The findings of that study showed that minimally invasive treatment was associated with fewer blood transfusions and a lower incidence and severity of postoperative complications in all age groups. It is interesting to note that laparoscopic surgery appears to offer an advantage over open surgery even among women aged 80 years or older. These data on laparoscopic surgery have been confirmed by studies comparing robotic and open abdominal surgery, thus showing that a minimally invasive approach in general may carry significant advantages in terms of perioperative morbidity.

**Role of Lymphadenectomy**

The issue regarding the usefulness and extent of lymph node dissection in patients with endometrial cancer remains a more controversial topic. The International Federation of Gynecology and Obstetrics (FIGO) staging system published in 2009 reaffirmed that assessment of nodal status is an integral part of ascertaining stage of disease. In comparison with the previous edition (1988), the 2009 update introduced a new distinction between two categories of stage IIIC disease (i.e., stage IIIC1 disease, with only pelvic node positivity, and stage IIIC2 disease, with positive paraaortic nodes), thus implicitly stressing the importance of exploring both of these two node-bearing areas to optimally assess the extent of disease.

Two studies have highlighted several points with regard to the usefulness and overall acceptability of extended full nodal dissection. Neither trial demonstrated a survival benefit for pelvic nodal sampling or complete lymphadenectomy versus no lymphadenectomy. More recently, evidence has suggested that sentinel lymph node mapping may become the new standard of care in the lymph node evaluation of patients with endometrial cancer.
Therapeutic Value of Lymphadenectomy

The value of nodal assessment to predict patterns of failure and prognosis has never been questioned. On the other hand, with regard to possible therapeutic implications, several nonrandomized studies have suggested that systematic pelvic and paraaortic lymphadenectomy may provide a survival benefit in patients at high risk of nodal metastasis compared with no lymphadenectomy.\textsuperscript{14,15} However, the findings of two prospective randomized trials published in 2009 (the ASTEC trial and the LINCE trial)\textsuperscript{16,17} negated the findings of previous retrospective series. In the ASTEC trial, 1400 patients who underwent surgery for apparent early-stage endometrial cancer (stage I) were randomized to pelvic lymphadenectomy or no lymphadenectomy. The same allocation had been used in the Italian LINCE trial conducted by Benedetti Panici and colleagues, in which 540 women were randomized 1:1 for pelvic lymphadenectomy versus no lymphadenectomy, with 30% of patients in the lymphadenectomy arm receiving additional paraaortic dissection. However, major criticisms have been made regarding the study designs of both trials, particularly because the number of lymph nodes removed in the lymphadenectomy arm was relatively low and because the decision regarding adjuvant treatment according to lymph node status was not part of the protocols. Moreover, both trials shared the bias of not effectively selecting patients at high risk for nodal metastasis (the ASTEC trial included all patients with endometrial cancer without exclusion of early-stage and low-risk disease). Also, the low percentage of patients with positive nodes in the two studies (9% in the ASTEC trial, 13% in the LINCE trial) had the effect of inevitably diluting the possible (if any) therapeutic benefit of lymphadenectomy.\textsuperscript{18}

A large retrospective trial (the SEPAL study [Survival Effect of Para-aortic Lymphadenectomy in Endometrial Cancer]) compared two different approaches—systematic pelvic versus systematic pelvic and paraaortic lymphadenectomy—and demonstrated a survival advantage in patients who underwent nodal dissection in both areas.\textsuperscript{19} This advantage was even more pronounced when the analysis was limited to patients with intermediate- or high-risk disease. However, even if the discrepancy in adjuvant treatment between patients who underwent pelvic and paraaortic lymphadenectomy (77% received adjuvant chemotherapy) and patients who underwent pelvic lymphadenectomy alone (45%) could represent an important bias of the study, a subsequent analysis performed in the same groups of patients focusing on the initial failure site demonstrated a higher recurrence rate for women who underwent pelvic without paraaortic lymphadenectomy (9.5% vs. 1.3%).\textsuperscript{20} Despite the lack of survival benefit reported in the two prospective trials,\textsuperscript{12,16} lymph nodal evaluation remains crucial in patients with intermediate- and high-risk disease to identify patients in whom adjuvant therapy may be avoided. This will ultimately prevent unnecessary overtreatment and inappropriate undertreatment.\textsuperscript{21}

Sentinel Nodes in Endometrial Cancer

In recent years, the possibility of performing sentinel node detection (SND) in patients diagnosed with endometrial cancer has been proposed. The theoretical advantages of this approach include the possibility of assessing nodal status with minimal or limited dissection of the retroperitoneal node-bearing areas. It appears evident that the omission of full lymphadenectomy not only reduces the overall operative time and surgical difficulty but also has the potential to minimize the rate of both intraoperative and postoperative lymphadenectomy-related complications. If proven reliable, SND may be proposed as a balanced compromise between no nodal dissection and full, systematic, extended, and time-consuming nodal dissections.

Historically, sentinel node identification has been proposed and validated in the management of melanoma, breast cancer, and vulvar cancer. For more than a decade, researchers have investigated the role of SND in endometrial cancer, but a decisive increase of the application of this technique to uterine malignancies has been achieved only recently with the use of indocyanine green, a fluorescent tracer that can be easily detected during a minimally invasive surgical procedure (whether laparoscopic or robotic) by using endoscopic cameras with a near infrared high-intensity light source for detecting fluorescence.

Indocyanine green has been shown to be superior to the two traditional tracers (i.e., technetium 99 and blue dye) in terms of both detection rate and bilateral optimal mapping.\textsuperscript{22} Three possible sites of dye injection have been proposed: cervical, peritumoral (under hysteroscopic guidance), and subserosal. At present, cervical injection is the most commonly used approach because of its intrinsic simplicity and higher detection rate compared with the other methods.\textsuperscript{23} However, some doubts have been raised about the ability of cervical injection to permit reliable assessment of the true lymphatic drainage of endometrial malignancies. It is hypothesized that tracer injected into the cervix may migrate, following the drainage of uterine venous vessels through the parametrium to the pelvic nodal basins. However, uterine lymphatic drainage is complex and also involves migration through the infundibulopelvic ligaments up to the high paraaortic nodes. The low rate of detection of sentinel nodes in the paraaortic area (approximately 5%) when the tracer is injected into the cervix seems to confirm these doubts.\textsuperscript{24} Nevertheless, results of the application of sentinel node techniques in endometrial cancer appear encouraging, with detection rates ranging from 60% to 100% and false-negative rates of less than 5% if strict protocols are followed.\textsuperscript{25}

A recent retrospective study combining data from Memorial Sloan Kettering Cancer Center and the Mayo Clinic reported the results of two different approaches to nodal assessment in low-risk endometrial cancer patients (low risk was defined as endometrioid histology and myometrial invasion <50%). At Memorial Sloan Kettering Cancer Center, an algorithm involving sentinel lymph node removal alone was followed from 2006 to 2013. Conversely, at the Mayo Clinic, systematic pelvic and paraaortic lymphadenectomy was routinely performed from 2004 to 2008 in a similar population of patients. The results of the study are of value and show that, despite a lower number of lymph nodes removed when the sentinel lymph node–only algorithm was followed, the overall percentage of positive nodes was higher at Memorial Sloan Kettering Cancer Center than at the Mayo Clinic (5.1% vs 2.6%; \(P = .03\)),\textsuperscript{26} probably because of ultrastaging techniques applied to sentinel nodes. Of interest, the 3-year disease-free overall survival rate was similar in the two institutions (Fig. 9.1).

At present, there are no definitive data regarding the superiority of SND over complete nodal assessment in endometrial cancer patients. In particular, several areas require additional research and clarification:

- The role of SND in high-risk endometrial cancer patients.
- The impact of SND on adequately targeting postoperative treatment and in decreasing overall morbidity.
- The impact of SND on detection of micrometastases (0.2–2 mm) or isolated tumor cells (<0.2 mm), which are not usually discovered with traditional pathology protocols applied to systematic lymphadenectomy.
• Whether the increased diagnostic ability (and the parallel increase in patients undergoing adjuvant treatment) may mitigate at least in part the advantage provided by SND in terms of reducing unnecessary surgical morbidity.

• The role of SND without associated lymphadenectomy in patients with positive nodes; whether extensive removal of pelvic and paraaortic nodes in women with lymphatic spread of disease may improve survival is still a subject of debate.

**Indications for Lymphadenectomy**

Lymphatic spread of endometrial cancer is unlikely in certain patients with small primary tumors, superficial or absent myometrial invasion, and low-grade disease. As a consequence, it has been estimated that about 30% of affected women (deemed not at risk) have almost no risk of lymphatic spread. This allows the avoidance of lymphadenectomy in almost one-third of patients, without consequences on adjuvant treatment decision making and survival (Fig. 9.2).²⁷

Recent studies have assessed the risk of pelvic and paraaortic nodal metastases among patients considered at risk (i.e., excluding women with the characteristics shown in Fig. 9.2). Results of these reports are summarized in Table 9.1.²⁸

As shown in Table 9.1, the risk of paraaortic metastasis in endometrial cancer patients with myometrial invasion of less than 50% is low (2.2%). On the other hand, when myometrial invasion is greater than 50%, the risk of nodal metastasis is high, including paraaortic dissemination, particularly in grade 3 endometrioid tumors. It is well known that paraaortic lymphadenectomy up to the level of the renal vessels is potentially associated with significant intraoperative and postoperative morbidity. Given that paraaortic dissemination of endometrioid endometrial cancer is uncommon, a study from the Mayo Clinic has aimed to identify a subgroup of women at low risk of lymphadenectomy safely omitted if:

- Endometrioid adenocarcinoma
- No macroscopic evidence of extrauterine disease
- No synchronous cancer

**FIG. 9.2** Patients in whom it is possible to safely avoid lymph node dissection (risk of nodal spread, 0.3%). (Adapted from Mariani A, Dowdy SC, Cliby WA, et al. Prospective assessment of lymphatic dissemination in endometrial cancer: a paradigm shift in surgical staging. *Gynecol Oncol*. 2008;109[1]:11–18. Used with permission.)

**TABLE 9.1** Lymph Node Metastasis Stratified by Grade and Myometrial Invasion in Endometrioid and Nonendometrioid Endometrial Cancer Without Macroscopic Extrauterine Spread: 2004–2008 Mayo Clinic Experience of 457 Patients Who Underwent Lymphadenectomy

<table>
<thead>
<tr>
<th>Type I Histology</th>
<th>Site of Nodal Metastasis</th>
<th>Grade</th>
<th>Myometrial Invasion, No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>&lt;50%</td>
<td>≥50%</td>
</tr>
<tr>
<td>Pelvic</td>
<td>1</td>
<td>5/130 (3.8)</td>
<td>5/33 (15.2)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>6/82 (7.3)</td>
<td>7/41 (17.1)</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>2/29 (6.9)</td>
<td>6/17 (35.3)</td>
</tr>
<tr>
<td>Paraaortic</td>
<td>1</td>
<td>1/119 (0.8)</td>
<td>3/32 (9.4)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>4/76 (5.3)</td>
<td>8/29 (20.5)</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0/28 (0)</td>
<td>4/16 (25)</td>
</tr>
<tr>
<td>Isolated</td>
<td>1</td>
<td>0/114 (0)</td>
<td>0/27 (0)</td>
</tr>
<tr>
<td>paraaortic</td>
<td>2</td>
<td>1/70 (1.4)</td>
<td>4/32 (12.5)</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0/26 (0)</td>
<td>3/11 (27.3)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type II Histology</th>
<th>Site of Nodal Metastasis</th>
<th>Grade</th>
<th>Myometrial Invasion, No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No Myome-</td>
<td>&lt;50%</td>
</tr>
<tr>
<td>Pelvic</td>
<td>2</td>
<td>0/1 (0)</td>
<td>0/1 (0)</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3/24 (12.5)</td>
<td>7/36 (19.4)</td>
</tr>
<tr>
<td>Paraaortic</td>
<td>2</td>
<td>0/1 (0)</td>
<td>0/1 (0)</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>2/21 (9.5)</td>
<td>6/33 (18.2)</td>
</tr>
<tr>
<td>Isolated</td>
<td>2</td>
<td>0/1 (0)</td>
<td>0/1 (0)</td>
</tr>
<tr>
<td>paraaortic</td>
<td>3</td>
<td>1/18 (5.6)</td>
<td>1/26 (3.8)</td>
</tr>
</tbody>
</table>

metastases in this area and in whom paraaortic lymphadenectomy may be safely avoided. The main findings of this study are summarized in Table 9.2.

It is interesting to note that, in general, less than 4% of women with endometrioid subtypes have metastasis or failure at the level of the paraaortic nodes. Patients who may safely forego paraaortic lymphadenectomy include those with endometrioid histology, no or superficial myometrial invasion, negative pelvic nodes, and no lymphovascular space involvement.

### Complications of Pelvic and Paraaortic Lymphadenectomy

The exact role of lymphadenectomy in endometrial cancer cannot be accurately defined outside of the assessment and complications associated with the procedure. Historical series of open abdominal surgical procedures have shown that the performance of pelvic and paraaortic lymphadenectomy is associated with an increased incidence of vascular injuries, deep vein thrombosis, lymphocysts, and death from pulmonary embolism. A previous study analyzed the acute morbidity and mortality of 812 patients who underwent surgery for endometrial cancer, finding a higher incidence of vascular lacerations, deep vein thrombosis, and pelvic lymphocysts in women who underwent lymphadenectomy compared with those who underwent only hysterectomy and bilateral salpingo-oophorectomy. Nine (1.1%) of the 812 patients included in the study died after surgery; eight of the nine were in the group of patients who underwent lymphadenectomy. Of note, five of these eight postoperative deaths were associated with thromboembolism. The performance of lymphadenectomy was the most important independent variable associated with postoperative deep vein thrombosis and pulmonary embolism.

In 2001, Franchi and colleagues published a detailed analysis of postoperative complications after pelvic lymphadenectomy performed by means of laparotomy for the surgical staging of endometrial cancer. Results of this study are summarized in Table 9.3.

Also in the study by Franchi and colleagues, lymphadenectomy was associated with a higher incidence of postoperative complications. It must be emphasized that the removal of more than 14 pelvic nodes was the only factor independently associated with the development of at least one complication and that the removal of more than 19 lymph nodes was the only factor independently associated with the development of two postoperative complications.
The advent of minimally invasive procedures has dramatically reduced morbidity. Two landmark studies on a large number of patients who underwent extensive laparoscopic lymphadenectomy were published in 2004 to 2006. The first study included 650 patients operated on by Schneider and Kohler’s group in Jena, Germany, and the second study included 1000 patients of Querleu’s group in Lille and Toulouse, France. Both studies demonstrated that, in referral centers, laparoscopic lymphadenectomy is a safe procedure and that it is associated with a high nodal yield and a very low rate of intraoperative and postoperative complications.

The rate of major vascular complications was 1.1% in the study by Kohler and colleagues, with a slightly higher prevalence of venous (57.1%) over arterial injuries (42.9%). Of note, four of the seven vascular complications observed were resolved laparoscopically with no need for conversion to an open procedure. In the report by Querleu and colleagues, the rate of intraoperative and early postoperative complications and the percentage of patients in whom lymphocyst formation occurred were 2.0%, 2.9%, and 7.1%, respectively. Of the 20 intraoperative complications, 11 (1.1% of the entire cohort) were vascular injuries (4 during pelvic lymphadenectomy and 7 during paraaortic lymphadenectomy), 3 were bowel lesions, 3 were ureteral injuries, and 3 were nerve injuries (intraoperative obturator nerve transection). Table 9.4 shows the incidence and type of complications in the two cited studies. Table 9.5 focuses on the incidence and characteristics of major vascular complications during laparoscopic pelvic and paraaortic lymphadenectomy.

In general, looking at the number of complications in the largest published series from tertiary care centers, laparoscopic procedures appear to be associated with a decrease in the overall rate of surgical complications. Among the most common (although usually not life-threatening) postoperative complications of lymphadenectomy are lymphocyst formation, lymphorrhea, or lymphedema. A study conducted at the University of Insubria compared the incidence of these types of lympathic complications in women undergoing laparoscopic versus open procedures. The findings of that analysis showed that the incidence of lymphocysts is significantly lower if minimally invasive surgery is performed compared with standard laparotomy, whereas no significant differences between the two approaches were reported in terms of lymphorrhea and lymphedema. Among the possible explanations for these results, the most

### Table 9.3 Incidence of Complications in a Series of 206 Patients Who Underwent Surgical Intervention for Endometrial Cancer at the University of Insubria

<table>
<thead>
<tr>
<th>Complication</th>
<th>Incidence, No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulmonary embolism</td>
<td>1 (0.5)</td>
</tr>
<tr>
<td>Relaparotomy for bowel obstr</td>
<td>3 (1.5)</td>
</tr>
<tr>
<td>Relaparotomy for hemostasis</td>
<td>3 (1.5)</td>
</tr>
<tr>
<td>Sepsis</td>
<td>2 (1)</td>
</tr>
<tr>
<td>Injury to abdominal organs</td>
<td>2 (1)</td>
</tr>
<tr>
<td>Lymphocytes</td>
<td>18 (8.7)</td>
</tr>
<tr>
<td>Febrile morbidity</td>
<td>4 (1.9)</td>
</tr>
<tr>
<td>Deep vein thrombosis</td>
<td>4 (1.9)</td>
</tr>
<tr>
<td>Incisional hernia</td>
<td>6 (2.9)</td>
</tr>
<tr>
<td>Cystitis and/or hematuria</td>
<td>18 (8.7)</td>
</tr>
<tr>
<td>Wound infections</td>
<td>4 (1.9)</td>
</tr>
</tbody>
</table>


### Table 9.4 Incidence and Type of Complications in the Studies by Kohler and Colleagues (N = 650 Patients) and Querleu and Colleagues (N = 1000 Patients)

<table>
<thead>
<tr>
<th>Site or Type of Injury</th>
<th>Kohler and Colleagues (2004), No. (%)</th>
<th>Querleu and Colleagues (2006), No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vascular injury</td>
<td>7 (1.1)</td>
<td>11 (1.1)</td>
</tr>
<tr>
<td>Bowel injury</td>
<td>3 (0.5)</td>
<td>8 (0.8)</td>
</tr>
<tr>
<td>Ureteric injury</td>
<td>0 (0)</td>
<td>6 (0.6)</td>
</tr>
<tr>
<td>Nerve injury</td>
<td>0 (0)</td>
<td>3 (0.3)</td>
</tr>
<tr>
<td>Neural irritation</td>
<td>16 (2.5)</td>
<td>2 (0.2)</td>
</tr>
<tr>
<td>Chylous ascites</td>
<td>3 (0.5)</td>
<td>15 (1.5)</td>
</tr>
<tr>
<td>Lymphedema</td>
<td>6 (0.9)</td>
<td>15 (1.5)</td>
</tr>
<tr>
<td>Lymphocyst</td>
<td>3 (0.5)</td>
<td>71 (7.1)</td>
</tr>
<tr>
<td>Hematoma</td>
<td>0 (0)</td>
<td>6 (0.6)</td>
</tr>
<tr>
<td>Abscess</td>
<td>1 (0.2)</td>
<td>2 (0.2)</td>
</tr>
<tr>
<td>Other</td>
<td>4 (0.6)</td>
<td>11 (1.1)</td>
</tr>
</tbody>
</table>

Adapted with permission from Kohler and colleagues and Querleu and colleagues.

### Table 9.5 Incidence and Type of Vascular Injury in the Studies by Kohler and Colleagues (N = 650 Patients) and Querleu and Colleagues (N = 1000 Patients)

<table>
<thead>
<tr>
<th>Site of Vascular Injury</th>
<th>Kohler and Colleagues (2004), No. (%)</th>
<th>Querleu and Colleagues (2006), No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Veins</td>
<td>57.2%</td>
<td>27.3%</td>
</tr>
<tr>
<td>Vena cava</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Internal iliac</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>External iliac</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Arteries</td>
<td>42.8%</td>
<td>72.7%</td>
</tr>
<tr>
<td>Aorta</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Inferior mesenteric</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Common iliac</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>External iliac</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Ovarian</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Superior vesical</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Obturator</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Adapted with permission from Kohler and colleagues and Querleu and colleagues.
plausible is that laparoscopy is associated with decreased formation of adhesions and consequently a lower likelihood of lymphatic fluid entrapment after lymph node dissection. A recent study performed at the Mayo Clinic enrolling more than 1000 consecutive surgically treated patients suggested a significant correlation between lymphadenectomy and lymphedema, with an attributable risk of 23% for patients who underwent lymphadenectomy compared with hysterectomy alone. Moreover, pelvic and paraaortic lymphadenectomy, as well as open surgical procedures, have been shown not only to affect the patients’ quality of life but also to be strongly associated with a marked increase in costs of approximately US $4500 (calculated as year-2010 Medicare dollars) per patient undergoing staging for endometrial cancer.

Vascular Anatomic Variations in the Paraaortic Area

One of the major contributors to complications during paraaortic lymphadenectomy is the impact of vascular anomalies. Although the pelvis is seldom affected, the paraaortic area is not infrequently the site of possible anatomic variants that are not always recognized preoperatively. Authors reporting the findings of several series of in vivo and cadaveric dissections have indicated a consistent incidence of vascular anomalies in the paraaortic region, ranging from 17% to 44%. An anomaly of the renal vessels is the most commonly described. An accessory left lumbar vein draining into the left renal vein is the most common, followed by the polar renal arteries and circumaortic left renal vein. A precaval right renal artery has been described in about 5% of patients. Retroaortic renal veins are less common, as are duplicated venae cavae (Fig. 9.3 and Table 9.6).

Tips and Tricks to Avoid Vascular Injuries During Lymphadenectomy

- Carefully review preoperative imaging studies before the operation.

Role of Oophorectomy at the Time of Hysterectomy

The guidelines from the ESMO-ESGO-ESTRO Consensus Conference on Endometrial Cancer, held in Milan in 2015, stated that ovarian preservation may be taken into account in young patients; however, bilateral salpingectomy is recommended. Candidates for ovary-sparing surgery should be carefully selected, with specific attention paid not only to the age of the patient but also to her family oncologic history. A study conducted at the Mayo Clinic showed that the risk of synchronous ovarian cancer at the time of hysterectomy for endometrial cancer is 6% in women younger than 50 years and with no family history of ovarian or breast cancer. However, the risk increases to 27% in women younger than 50 years with a positive family history of ovarian or breast cancer (Table 9.7).

Ovarian conservation has been shown to be a safe option with no unfavorable implications for oncologic outcomes in young women diagnosed with early-stage endometrial cancer. However, as recently reported in a meta-analysis of seven

---

**TABLE 9.6** Incidence of Vascular Anomalies in the Paraaortic Area

<table>
<thead>
<tr>
<th>Incidence</th>
<th>Anomaly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common</td>
<td>Polar renal arteries</td>
</tr>
<tr>
<td></td>
<td>Accessory lumbar vein draining into the left renal vein</td>
</tr>
<tr>
<td>Uncommon</td>
<td>Precaval right renal artery</td>
</tr>
<tr>
<td></td>
<td>Retroaortic left renal vein</td>
</tr>
<tr>
<td></td>
<td>Circumaortic left renal vein</td>
</tr>
<tr>
<td>Rare</td>
<td>Duplicated vena cava</td>
</tr>
<tr>
<td></td>
<td>Right renal artery below the level of the right renal vein</td>
</tr>
<tr>
<td>Extremely rare</td>
<td>Ascending left renal artery at the level of the inferior mesenteric artery</td>
</tr>
</tbody>
</table>

**TABLE 9.7** Risk of Ovarian Cancer at Time of Hysterectomy for Endometrial Cancer: According to Age and Family History of Ovarian or Breast Cancer

<table>
<thead>
<tr>
<th>Age &lt;50</th>
<th>Family History of Breast or Ovarian Cancer*</th>
<th>Ovarian Cancer, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>No</td>
<td>6 (4/68)</td>
</tr>
<tr>
<td>Yes</td>
<td>Yes</td>
<td>27 (3/11)</td>
</tr>
<tr>
<td>No</td>
<td>No</td>
<td>1 (10/711)</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>5 (5/106)</td>
</tr>
</tbody>
</table>

*At least one first-degree relative with malignancy.

retrospective studies, women whose ovaries were preserved had a slightly but not significant impairment of disease-free survival. However, despite the growing literature supporting this approach, the majority of young women with early-stage endometrial cancer still undergo oophorectomy at the time of operation. Because the overall risk of metastatic microscopic ovarian involvement, not detectable at time of operation, has been estimated to be 0.8% in patients with clinical stage I FIGO grade 3 disease with deep myometrial invasion (250%), detailed preoperative counseling should be offered to this group of patients before the operation.

**Preoperative Evaluation**

Abnormal uterine bleeding (whether postmenopausal or intermenstrual) is the most common symptom of endometrial cancer. The diagnosis should always be confirmed by endometrial biopsy, with or without hysteroscopy. Histology and grade of endometrial cancer are important predictors of disease outcome and of nodal involvement. A thorough evaluation of the biopsy specimen should be performed by a gynecologic pathologist specializing in cancer. It is imperative to have not only a histologic diagnosis but also a designation of the grade to guide further evaluation and surgical approach. It has been shown that preoperative endometrial sampling is only a modest predictor of surgical pathologic findings, and it could underestimate the risk of disease spread and recurrence.

At some institutions, evaluation of the lymph nodes may be guided by a frozen section of the uterus and the adnexa at the time of operation; however, it should be stressed that this practice should be reserved only for centers where there is vast expertise in frozen section evaluation of the uterus in the setting of endometrial cancer. In the majority of cases, the surgical treatment for patients with cancer of the corpus uteri has to be planned in advance, and as a result, preoperative workup is crucial in order to choose the most appropriate treatment.

In general, routine evaluation of a patient with endometrial cancer entails a thorough physical examination, along with routine blood work, including complete blood count, and a chest radiograph. A pelvic ultrasound examination is recommended in the setting of minimally invasive surgery to ensure that the uterus will be removed intact through the vagina. This is particularly important in obese patients, in whom an assessment of uterine size at pelvic examination may be challenging because of the patient’s body habitus. Abdominal computed tomography can be scheduled in order to identify possible extrapelvic disease, in particular at the level of the liver and retroperitoneal nodes in patients with high-risk histologic types. Dynamic contrast-enhanced magnetic resonance imaging appears accurate in assessing cervical involvement and depth of myometrial invasion, and it can play a role, especially in centers where intraoperative frozen section analysis is not available. Of note, transvaginal ultrasonography has been described as a reliable and less expensive alternative for evaluation of the depth of myometrial invasion; however, the high interoperator variability of this method still represents a major limitation to its routine use. Although positron emission tomography has high accuracy in detecting distant metastases, its use is limited because of the cost and relatively low risk of hematogenous metastatic spread of endometrioid endometrial cancer. Cystoscopy should be considered when stage IVA disease is suspected.

**Perioperative Management**

Preoperative mechanical bowel preparation should be avoided because no evidence supports the routine use of laxatives before routine surgical procedures for endometrial cancer, irrespective of the type of approach. Prophylactic antibiotics should be administered approximately 30 minutes before skin incision. Antithrombotic prophylaxis should be administered with low-molecular-weight heparin according to international guidelines.

**Surgical Technique**

Because minimally invasive surgical approaches are discussed separately in detail in other chapters of this book, this section focuses only on the technique of the traditional open abdominal surgical approach for hysterectomy and pelvic and paraaortic lymphadenectomy.

**Hysterectomy**

Removal of the uterus in early-stage endometrial cancer requires a total simple extrafascial hysterectomy (type I according to the Piver-Rutledge classification or type A according to the Querleu-Morrow classification). The operation includes the complete removal of the uterus and cervix with no removal of the paracervix. The position of the ureters is determined by palpation or direct vision, and the paracervix is transected medial to the ureter and lateral to the cervix. The uterosacral ligaments and vesicouterine ligaments are transected adjacent to the uterus, and the paracolpos is preserved.

**Open Abdominal Approach**

The patient is placed in a supine position with an indwelling vesical Foley catheter and pneumatic compression stockings on the lower extremities. Depending on clinical factors, abdominal entry can be achieved through either a vertical or a transverse incision; the vertical midline incision offers better visualization of the operative field and is necessary when paraaortic lymphadenectomy is planned (Fig. 9.4).

**Step 1: Exploration of the Abdomen**

A self-retaining retractor may be used to optimize the exposure. Careful exploration of the peritoneal cavity should be performed to rule out the presence of intra-abdominal disease. All the peritoneal surfaces should be inspected, or at least palpated. The surgical steps of hysterectomy for endometrial cancer are equivalent to those of standard hysterectomy in cases of benign disease. Although peritoneal cytologic evaluation was included in staging procedures in the past, collection of cytologic specimens is no longer mandatory. However, positive peritoneal cytologic findings have been demonstrated to be an independent prognostic factor for women diagnosed with type II endometrial cancer.

**Step 2: Exposure of the Retroperitoneal Spaces and Ureteral Identification**

The uterus is grasped at the junction of the round ligament and the lateral aspect of the uterine fundus bilaterally. This should include the round, utero-ovarian, and broad ligaments. Vigorous traction is performed to elevate the uterus and to ensure adequate exposure of the supportive structures. The first step...
Step 3: Adnexal Removal or Sparing

When concomitant bilateral oophorectomy is planned, the infundibulopelvic ligaments are isolated, clamped, divided, and ligated with 1-0 delayed absorbable suture. Alternatively, a vessel-sealing device may be used. To obtain adequate and safe isolation of the infundibulopelvic ligament, the posterior aspect of the broad ligament is opened, creating a window beneath the ovarian vessels, making sure that the ureter lies below the peritoneal opening. If the adnexa are to be preserved, clamping, cutting, and ligation are performed at the level of the utero-ovarian ligament.

Step 4: Development of the Vescicouterine Fold and Caudal Reflection of the Bladder

While cephalad traction is applied to the uterus, the peritoneum covering the anterior aspect of the broad ligament is opened to the level of the vescicouterine fold, elevated with long forceps, and incised with scissors or electrocautery. The bladder is mobilized inferiorly from the anterior surface of the uterus and cervix. Gentle countertraction on the bladder can help to safely accomplish this step.

Step 5: Division of the Cardinal and Uterosacral Ligaments

Once the broad ligament has been opened both anteriorly and posteriorly and the bladder has been mobilized and detached from the anterior aspect of the cervix, the uterine vascular pedicles are visualized. At this time, clamping, cutting, and ligation with 1-0 delayed absorbable sutures is accomplished, bilaterally.

is ligation and transection of the round ligaments. The pelvic peritoneum is then opened parallel to the external iliac vessels and lateral to the infundibulopelvic ligament to obtain access to the retroperitoneal spaces (Fig. 9.5). The ureters are visualized, and one should be certain to maintain full visualization of these vital structures for the duration of the operation.

FIG. 9.4 Surgical steps for the vertical midline incision.

FIG. 9.5 Access to the retroperitoneum.
Chapter 9  Hysterectomy With Pelvic and Paraaortic Lymphadenectomy

An additional straight clamp positioned distally to the level of the incision can be useful to avoid back bleeding. Then the cardinal and uterosacral ligaments are clamped, cut, and ligated, bilaterally (Fig. 9.6).

Step 6: Colpotomy and Vaginal Closure

Colpotomy is performed by clamping below the cervix bilaterally, using curved Lainz clamps and cutting above the clamps with Jorgenson scissors. After removal of the uterus en bloc, the vaginal cuff is closed, starting from the right vaginal angle and using 1-0 delayed absorbable suture, with running submucosal closure. Some surgeons suggest a second layer of running suture to complete the vaginal closure (Fig. 9.6). Alternatively, one may use a single barbed suture for closure of the vaginal cuff.

Landmarks for Pelvic and Paraaortic Lymphadenectomy

Pelvic Lymphadenectomy

The boundaries for a systematic pelvic lymphadenectomy are the following: (1) proximally—the common iliac artery; (2) distally—the circumflex iliac vein; (3) laterally—the pelvic side wall and the mid–psoas muscle; (4) medially—to the hypogastric artery and the obliterated umbilical artery (terminal branch); and (5) dorsally—the obturator nerve and obturator fossa (Fig. 9.8).

Paraaortic Lymphadenectomy

Boundaries for paraaortic lymphadenectomy are the following (from right to left): right psoas muscle; right ureter (medial to the psoas muscle and lateral to the inferior vena cava, crossing the bifurcation of the common iliac artery); vena cava (lateral to the aorta); aorta and common iliac arteries; superior hypogastric plexus (superficially, below the bifurcation); left common iliac vein; right and left renal arteries and left renal vein; left ureter; sigmoid colon; lumbar vessels (artery and vein); and left psoas muscle.

Sympathetic and parasympathetic nerves (sympathetic chain, postganglionic sympathetic fibers, and hypogastric plexus) can be preserved to prevent bladder or rectal dysfunction related to the procedure (nerve-sparing procedure) (Fig. 9.9).

Lymphadenectomy: Pelvic Phase

Before the dissection is begun, an accurate exposure of pelvic structures should be achieved; the ureters must be identified, freed, and retracted to adequately approach the region of the common iliac vessels. In the obturator fossa, it is necessary to isolate the obturator nerve up to its entrance to the obturator muscle.

Access to the Retroperitoneum

When lymphadenectomy is performed before hysterectomy, the retroperitoneum must be opened by incision of the round ligament, and the paravesical and pararectal spaces must be developed. The tissue from the psoas muscle can be dissected lateral to the external and common iliac vessels. The genitofemoral nerve should be identified, freed, and spared, and the lymphatic tissue should be systematically removed from the external iliac vessels.

An entry in the obturator fossa must be created between the external iliac vein and the psoas muscle to free the tissue ventrally to the symphysis. The obturator nerve can be identified from a lateral or medial approach and preserved.

Lymph Node Dissection

The lymphatic tissue is mobilized, freed from the base of the fossa, dissected, and removed en bloc. Cranially, the common iliac lymph nodes must be removed up to the level of the bifurcation of the aorta. The vessels must be retracted medially, and the tissue must be removed between the vessel and psoas muscle. Once the tissue has been freed from the bifurcation of the aorta and promontory, it can be removed en bloc (Fig. 9.10).

Lymphadenectomy: Paraaortic Phase

Before the dissection is begun, it is important to identify the course of both ureters and their crossing at the level of the common iliac vessels. Two types of peritoneal incisions are commonly used to gain adequate access to the node-bearing paraaortic region: (1) an incision along the paracolic gutters to mobilize the bowel en bloc or (2) an incision caudal to the root of the mesentery along the right common iliac artery and anterior aspect of the aorta. The more commonly used incision is the one at the mesenteric base; at this level, the peritoneum can be easily incised by using monopolar coagulation, the intestine can be gradually released, and the small vessels can also be coagulated.

The lymphatic tissue can be freed from the aorta and inferior vena cava. The inferior mesenteric artery should be identified, and the lymphatic tissue should be removed up to the renal vein between the aorta and vena cava cranially. To maintain adequate vascular supply of the left colon, it is important to preserve the inferior mesenteric artery. However, in young women or in patients with no signs of atherosclerosis, the inferior mesenteric artery may be sacrificed when necessary to obtain adequate exposure to the left paraaortic nodes. The gonadal vessels must be identified bilaterally to avoid inadvertent injury to these structures (Fig. 9.11).

Left Paraaortic Lymph Node Removal

The next step is removal of the lymph nodes of the left paraaortic area to the left renal vein and the lymph nodes of the right paracaval area (to the right of the inferior vena cava) to the psoas muscle.
Intercavoaortic lymph nodes have to be dissected, with close attention paid to the cisterna chyli, because injury to this structure results almost invariably in chylous ascites. The last step is removal of the lymphatic tissue between the inferior mesenteric artery, aorta, and left common iliac artery (Fig. 9.12).

**Summary**

The surgical management of endometrial cancer continues to evolve, and new strategies for treatment are also evolving. The minimally invasive approach is now considered the standard of care in patients with this diagnosis; these procedures
FIG. 9.9 Superior hypogastric plexus and its ramifications in the promontorium (open abdominal view). (From University of Insubria.)

FIG. 9.10 Comprehensive illustration of the pelvic lymphadenectomy.
result in a much faster recovery time, and the oncologic outcomes are very similar to those after open surgical procedures. In addition, sentinel lymph node mapping is becoming the standard of care in most centers. This targeted approach allows for more precise detection of lymph node metastasis through the use of ultrastaging in the evaluation of such nodal tissue; at the same time, it avoids the potential comorbidities associated with full lymphadenectomy. For those in a setting where sentinel lymph node mapping is not available, traditional strategies must still be used; therefore this chapter has provided an in-depth analysis of the indications for hysterectomy and lymphadenectomy. It is critical to always follow the same steps in the procedure and to have a vast understanding of the anatomy in the pelvis and abdomen to ensure the best possible outcomes.

**Key Points**

- The optimal strategy for endometrial cancer staging is still under investigation, particularly with regard to the role of systematic pelvic and paraaortic lymphadenectomy.
- The introduction of sentinel node algorithms may have the potential to decrease surgical morbidity without reducing the ability to detect nodal involvement.
- A subgroup of low-risk women are very unlikely to derive any benefit from full lymphadenectomy and should undergo
only total extravesical hysterectomy plus bilateral salpingo-oophorectomy. When sentinel node mapping capacity is available, this should always be considered.

- Women without deep myometrial invasion, with absence of lymphovascular space invasion, and with negative pelvic nodes should not undergo paraaortic lymphadenectomy.
- Laparoscopic or robotic and open approaches have equivalent survival outcomes.
- Minimally invasive surgery is preferred over open procedures because of better perioperative outcomes and postsurgical quality of life.
- In experienced hands, a laparoscopic or robotic approach is feasible and advantageous in obese and elderly women.
- Surgeons should always review preoperative abdominal imaging to detect possible anatomic variants, particularly when planning a paraaortic lymphadenectomy.
- The creation of a peritoneal tent, suspending the peritoneum to the abdominal wall, may be useful during minimally invasive paraaortic lymphadenectomy.

References

The majority of patients with endometrial cancer have early-stage uterine-confined disease at presentation. However, many patients will still undergo a complete pelvic and sometimes paraaortic lymphadenectomy for staging purposes despite having disease confined to the uterus, resulting in prolonged operating time, additional cost, and potential long-term side effects such as lymphocyst formation and lower extremity lymphedema. Sentinel lymph node (SLN) mapping in endometrial cancer is an acceptable surgical staging strategy in many practices in the United States and provides a middle ground between a complete lymphadenectomy and no nodal evaluation. The technique has been refined over the past decade, and advances in near infrared imaging and improvements in laparoscopic and robotic optics have facilitated the use of this approach in minimally invasive surgery, which is the desired surgical approach in the majority of women with new clinical stage I endometrial carcinoma. Key factors to a successful SLN mapping procedure include the surgeon’s experience and adherence to the SLN algorithm published in 2012 and listed in the National Comprehensive Cancer Network (NCCN) guidelines since 2014. The Memorial Sloan Kettering Cancer Center (MSKCC) SLN algorithm (Fig. 10.1) is similar to a surgical checklist and is used to ensure standardization and reduce the false-negative rate of mapping. The algorithm takes into account the bilateral nature of pelvic nodal anatomy and the possibility of gross peritoneal or retroperitoneal disease and has been recently validated by several investigators, with good reproducibility of low false-negative rates.2-5

SLN mapping is an image-guided surgical procedure that is increasingly accepted in the staging of apparent uterine-confined endometrial cancer.6 Gould coined the term sentinel node in 1960 with his observations of carcinoma of the parotid gland.7 In 1977 Cabanas,8 a urologist working in Paraguay and as a surgical fellow at MSKCC, used lymphography and colored dye to define the lymphatic drainage of the penis and established the first clinical report of SLN in men with penile carcinoma. The concept of SLN mapping in endometrial cancer was introduced by Burke in 19969 from the MD Anderson Cancer Center, but the initial results were not encouraging and the concept gained popularity only later, in recent years, after the establishment of a cervical injection technique and standardization of the SLN mapping procedure with a surgical algorithm.1,10,11

### Importance of Lymph Node Assessment

Endometrial cancer is the most common gynecologic malignancy; approximately 10% to 15% of patients will have metastatic nodal disease, and nearly 15% of patients with grade 1 tumors at presentation preoperatively at office biopsy or dilatation and curettage will actually have higher grade disease at final pathologic review after hysterectomy12; therefore it is of utmost importance to stage and treat patients properly and limit missing undetected metastatic disease that could upstage the patient’s condition and change adjuvant therapy. For most gynecologic oncology practices, a low-risk endometrial cancer is a retrospective diagnosis, meaning that one does not know that the patient is at low risk until total hysterectomy has been done and the permanent pathologic assessment has been completed.

The majority of patients with newly diagnosed endometrial cancer will undergo initial surgical treatment that will include a total hysterectomy, bilateral salpingo-oophorectomy, and pelvic washings. Proper surgical staging, one of the most important prognostic factors, provides information on the actual extent of disease rather than on perceived risks based on uterine factors such as grade, histologic type, and depth of myometrial invasion, which helps tailor adjuvant therapy.13 Endometrial cancer frequently develops after menopause, and comprehensive lymphadenectomy in elderly women may be associated with side effects, such as lower extremity lymphedema and lymphocyst formation, which can negatively affect quality of life. The more pelvic lymph nodes removed, the greater the likelihood a patient will develop these side effects. The importance of lymph node assessment for proper surgical staging in this patient population cannot be stressed enough.14,15 In a study of 1289 patients with uterine corpus malignancies, 16 (3.4%) of 469 patients who had 10 or more lymph nodes removed at operation developed new postoperative symptomatic leg lymphedema, and this is likely an underestimation of the true incidence.16 Complete lymphadenectomy is also likely associated with greater operating time, prolonged anesthesia, and other potential untoward effects such as blood loss, vascular and nerve injury, and increased conversion rate from laparoscopy to laparotomy to complete the operation successfully. However, because accurate surgical staging is one of the most important prognostic factors, staging with the
SLN algorithm will provide the necessary pathologic information in the majority of women with apparent uterine-confined disease while limiting morbidity. The SLN algorithm, when applied for staging of all patients with newly diagnosed endometrial cancer, will at a minimum permit bilateral pelvic nodal assessment as part of the surgical staging. The SLN algorithm also increases surgical precision and avoids the “circumflex iliac” lymph nodes, which were often removed during routine bilateral pelvic lymphadenectomy. These nodes are usually benign, especially when other nodal areas are also negative. Removing these nodes frequently causes lymphatic obstruction in the lower extremity, increasing the risk of leg lymphedema. Unfortunately, many patients with early-stage endometrial cancer will undergo surgical procedures with insufficient nodal evaluation, with their nodes being palpated (with biopsy performed if they are enlarged), sampled, or completely ignored. Studies have shown rates of nodal assessment as low as 30%, although that percentage has increased as the importance of nodal assessment has been realized. Rates are higher when a gynecologic oncologist, as opposed to a general gynecologist, performs the operation (83% vs. 26% in one study). When surgical staging is inadequately performed, patients can be subjected to unnecessary adjuvant pelvic radiation therapy and its associated side effects. An MSKCC study showed that with the increase in lymph node assessment over a 12-year time period, there was an inverse decrease in the use of adjuvant whole-pelvis radiation therapy.

In an attempt to clarify clinical variables that affect overall survival in women with endometrial cancer, the classification and regression tree (CART) method, a form of recursive partitioning, was used in a study of 1035 International Federation of Gynecology and Obstetrics (FIGO) stage I to IV endometrioid endometrial cancer patients. The study showed that stage, age, adjuvant therapy, and the removal of 10 or more lymph nodes were predictors of overall survival in patients with stage I to IIIA disease. Only stage was a predictor of overall survival in patients with stage IIIC to IV disease. The CART method is a tree-building technique in which “predictor” variables are analyzed to determine how they affect an “outcome” variable (overall survival). The study confirmed the importance of age and surgical staging in influencing overall survival, but the increasing number of nodes removed was not a factor, particularly when a patient was assigned stage IIIC (node-positive disease), confirming the observation that a minimum number of nodes is needed to assign stage properly, but removal of more normal-appearing nodes, particularly in stage IIIC disease, did not improve overall survival.

The use of an SLN mapping algorithm in endometrial cancer patients is an acceptable staging strategy, providing a middle ground between the polarized schools of thought: complete lymphadenectomy and no nodal evaluation. Modern studies of SLN mapping have used the cervical injection technique in the majority of cases. In a study of 42 patients with grade 1 endometrioid endometrial cancer, the most common anatomic sites at which SLNs were identified were the internal iliac (52 [36%]), external iliac (43 [30%]), obturator (34 [23%]), and common iliac (11 [8%]) regions. Only five patients (3%) had paraaortic SLN involvement. Figs. 10.2 and 10.3 demonstrate the most common and less common drainage patterns following a cervical injection of dye.

Barlin and colleagues sought to evaluate clinical and pathologic factors that influenced overall survival and to determine if a paraaortic nodal assessment at the initial staging operation in patients with endometrial cancer affected overall survival. The study of 1920 patients who had at least one lymph node removed for staging, which also used CART analysis, showed no association between the removal of paraaortic nodes and overall survival ($P = .450$). The CART method did show that stage I versus stages II to IV and grades 1 or 2 versus grade 3 (a binary grading system of low vs. high grade) were predictors of overall survival. In other words, what appear to be important with regard to staging are the proper determination of uterine fundus–contained disease versus disease outside the uterine fundus and the pathologist’s determination of the grade of the tumor—low grade versus high grade (grade 1 or 2 endometrioid
disease is considered low grade, and grade 3 endometrioid or serous, clear cell carcinoma, or carcinosarcoma is considered high grade).

Sentinel Lymph Node Mapping Techniques

Historically, a radioactive tracer and blue dye were used to locate “hot” nodes or colored nodes. There are three different types of SLN mapping techniques based on site of injection: (1) uterine subserosal, (2) cervical (Fig. 10.4), and (3) endometrial, by means of hysteroscopy. The majority of current SLN users prefer a cervical injection. A rationale for use of a cervical injection includes the following: (1) the main lymphatic drainage to the uterus is from the parametria, and therefore a combined superficial (1–3 mm) and deep (1–2 cm) cervical injection is adequate; (2) the cervix is easily accessible; (3) the cervix in women with endometrial cancer is rarely distorted by anatomic variations, such as myomas, which sometimes make uterine serosal mapping impossible; (4) the cervix in women with endometrial cancer is rarely scarred from prior procedures such as conization or bulky tumor infiltration; and (5) uterine fundal serosal mapping does not reflect the parametrical lymphatic drainage of the uterus (the main route of drainage), and the majority of early-stage endometrial cancers do not have disease infiltrating and ulcerating the uterine fundal serosa.\(^5,11\) The main argument against cervical injection is that it has a lower paraaortic detection rate, as opposed to the hysteroscopic approach, but as is well documented, when the pelvic lymph nodes are negative for metastasis, disease is unlikely to be found in the paraaortic nodes (<5% isolated aortic nodal metastasis with negative pelvic nodes),\(^21\) and to date there has been no definitive, well-documented association between paraaortic nodal assessment and improved overall survival.\(^15\) In a large meta-analysis, Kang and colleagues reported a decrease in detection rates when the cervical method was not used and also recommended that the “subserosal injection only” technique be avoided because of decreased sensitivity.\(^22\) The importance of the cervical injection technique has also been recently supported by large review studies.\(^5\)

Colored Dye Injection

Colored dye (isosulfan blue 1% [Lymphazurin], methylene blue 1%, or patent blue 2.5% sodium [bleu patenté V sodique]) is injected while the patient is under anesthesia in the operating room. A spinal needle or Potocky-type needle is used to inject 4 mL of dye into the cervical submucosa and stroma. The injections are given at the 3- and 9-o’clock positions, which correspond to the parametria and will keep the bladder flap from being stained, which frequently occurs with injection at the 12-o’clock position. The dye should be injected slowly, at a rate of 5 to 10 seconds per quadrant.\(^23\)

Complications with blue dye are rare, consisting mostly of allergic reactions. Montgomery and colleagues reported a 1.6% incidence of allergic reactions and 0.5% incidence of hypotensive reactions in 2392 patients with breast cancer who underwent an SLN mapping procedure.\(^24\) Indocyanine green (ICG) recently emerged as an excellent dye for SLN mapping (Figs. 10.5–10.7). The 25-mg dry powder bottle is mixed with 20 mL of sterile water in the operating room, and a total of 2 to 4 mL is injected directly into the cervix in similar fashion to that for use of blue dye. The main contraindication is allergy to iodine, which is contained in the product currently available in the United States. The SLN detection rates with ICG and the bilateral SLN detection rates are comparable or superior to those with blue dye only or radiocolloid. ICG is currently the preferred imaging dye at many institutions, particularly those with robotic and laparoscopic platforms equipped with near infrared mapping technology.\(^25–27\)

New technologic advances continue to emerge to enhance the surgeon’s ability to visualize lymphatics. One method currently available for clinical use is color-segmented fluorescence (CSF), available on the PINPOINT system by Novadaq (Burnaby, British Columbia, Canada) (see Figs. 10.5–10.7). The current platform allows a picture-in-picture view with four modes simultaneously, including high-definition white light, Spy mode (black and white) with highest precision, PINPOINT mode (green overlay), and CSF mode. The CSF mode has the ability to provide a heat map that allows the surgeon to see the more dominant lymphatics and improve surgical precision to avoid removal of nonnodal tissue.
Obesity is an increasing problem affecting women with endometrial cancer, and SLN mapping maybe be an ideal solution for obese patients, in whom lymphadenectomy may be more challenging. Emerging data demonstrate that ICG cervical injection provides a superior bilateral detection rate compared with blue dye mapping and is likely equivalent to combined blue dye and technetium injections (Fig. 10.8). Recent published reports have confirmed that ICG with near infrared fluorescence results in higher overall and bilateral detection of SLNs in patients with endometrial cancer compared with blue dye. In general, successful mapping decreases with increasing body mass index (BMI) irrespective of dye used, but it is significantly improved with the use of ICG compared with blue dye. Based on these reports, most current gynecologic oncologists recommend use of ICG for patients with endometrial cancer, particularly obese patients. Even with advances in imaging technologies and increased use of ICG, mapping may not be successful in some patients. In these patients, use of the SLN algorithm will be critical to ensure adequate nodal evaluation. The following strategy will help minimize failed mapping:

1. Use a proper cervical injection technique.
2. Always perform SLN mapping as the first part of the operation after washings have been obtained and peritoneal evaluation has been performed.
3. Perform meticulous dissection at the beginning of the operation to limit blood staining of the retroperitoneum and to identify the lymphatic trunks.
4. Divide the round ligament.
5. Identify the obliterated umbilical vessel, and follow it cephalad to its origin from the internal iliac artery.
6. Look for lymphatic trunks crossing from medial to lateral over the obliterated umbilical vessel.
7. Open the paravesical and pararectal spaces gently.
8. Follow the trunks to the nodal basins. It may be necessary to look deeper in the hypogastric obturator basins to find the sentinel nodes.
9. If trunks are not seen crossing over the umbilical vessels, then look for lymphatic trunks in the mesoureter going to the presacral common iliac regions.
10. Adhere to the SLN algorithm to ensure the quality of the operation.

**Sentinel Lymph Node Mapping Algorithm**

Increasing surgical staging precision and maintaining a low false-negative rate are main priorities in any SLN program. Incorporating an SLN mapping algorithm significantly reduces the false-negative rate of the mapping procedure. Applying the MSKCC SLN algorithm reduces the false-negative rate to 2%, because the algorithm takes into account grossly enlarged suspicious nodes and includes a side-specific lymphadenectomy for the nonmapping hemipelvis (Table 10.1).
The SLN algorithm includes (1) peritoneal and serosal evaluation and washings; (2) retroperitoneal evaluation, including the removal of all SLNs and any suspicious nodes; and (3) if there is no mapping on a hemipelvis, a side-specific pelvic, common iliac, and interiliac lymph node dissection. A paraaortic lymphadenectomy is left to the attending physician’s discretion (see Fig. 10.1).1,2 This algorithm has been validated by other investigators.3,4,31

An acceptable SLN detection rate varies among practices, but a detection rate of 80% to 90% or greater is preferred.32 Khoury-Collado and colleagues reported on 115 patients with endometrial cancer treated from September 2005 through March 2009. The overall SLN detection rate was 85%. During the early phase of the study (September 2005 through December 2007), however, an SLN was identified in 50 (78%) of 64 cases, with two false-negative results, and during the late phase (January 2008 through March 2009), an SLN was identified in 48 (94%) of 51 cases, with no false-negative results. Detection rates increased from 77% to 94% (P = .033) during the two time periods, with surgeon experience (30 procedures or more) playing an integral role.31,32

With increasing surgeon experience and a corresponding increase in detection rates to 90% or greater, in addition to a decrease in false-negative rates as a result of adherence to the SLN algorithm, SLN mapping is becoming an established standard of care in many practices worldwide.

Sentinel Lymph Node Ultrastaging

Ultrastaging is an important component of the SLN algorithm. Ultrastaging is done when the initial SLN evaluation with hematoxylin and eosin (H&E) is negative for carcinoma. Ultrastaging has two basic components: serial sectioning and immunohistochemical staining.33 Data from Kim and colleagues suggest that ultrastaging should be limited to endometrial carcinomas with any degree of myoinvasion but not to nonmyoinvasive tumors.33 In endometrial carcinomas with any degree of myoinvasion, ultrastaging detects an additional 8% nodal positivity in the SLN over the initial H&E evaluation; however, if there is no myoinvasion, then ultrastaging detects only an additional 0.8% nodal positivity.33 The SLN ultrastaging protocol varies among institutions, but all include the two main components of serial sectioning and immunohistochemical staining. The SLN ultrastaging algorithm used at MSKCC is as follows (Fig. 10.9):34 SLNs are initially examined by use of routine H&E staining, and subsequent ultrastaging is performed if the initial H&E assessment is negative. Ultrastaging is performed by cutting two adjacent 5-μm sections at each of two levels, 50 μm apart, from each paraffin block lacking metastatic carcinoma. At each level, one slide is stained with H&E, and immunohistochemical staining is performed with the anticytokeratin AE1/AE3 (Ventana Medical Systems, Tucson, Arizona), for a total of five slides per block.33

Both SLNs and nonsentinel lymph nodes are routinely sectioned once and stained with H&E. The ultrastaging pathology protocol for SLNs is implemented if the SLN is negative on initial H&E staining. Ultrastaging reevaluates the presumably negative SLN at two additional levels, 50 μm apart, with an extra H&E-stained slide and immunohistochemical staining with the anticytokeratin AE1:AE3. Ultrastaging detects metastatic nodal disease including both micrometastases and isolated tumor cells. Gynecologic pathologists currently use definitions from the breast cancer literature published by the American Joint Committee on Cancer (AJCC; Breast Cancer Staging, seventh edition). Micrometastases in lymph nodes are defined as tumor cells larger than 2.0 mm; micrometastases are defined as a focus of metastatic cancer that is larger than 0.2 mm or consists of more than 200 cells 2.0 mm or smaller (these are considered positive nodes by most practices), and isolated tumor cells are defined as small clusters of cells not greater than 0.2 mm, or single tumor cells, or a cluster of fewer than 200 cells in a single histologic cross section. Isolated tumor cells may be detected with routine histologic examination or by immunohistochemical methods. There is significant controversy in gynecologic

![Fig. 10.8 Bilateral mapping rate in relation to body mass index (BMI). Blue dye versus indocyanine green (ICG). (From Eriksson AG, Montovano M, Beavis A, et al. Impact of obesity on sentinel lymph node mapping in patients with newly diagnosed uterine cancer undergoing robotic surgery. Ann Surg Oncol. 2016;23[8]:2522–2528.)](image)

### TABLE 10.1 Performance of Sentinel Lymph Node Technique Alone Compared With Algorithm for All Patients

<table>
<thead>
<tr>
<th>LN Positive</th>
<th>LN Negative</th>
<th>SLN Alone</th>
<th>Calculation</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLN positive</td>
<td>40</td>
<td>0</td>
<td>40</td>
<td>Sensitivity</td>
</tr>
<tr>
<td>SLN negative</td>
<td>7</td>
<td>354</td>
<td>361</td>
<td>Negative predictive value</td>
</tr>
<tr>
<td></td>
<td>47</td>
<td>354</td>
<td>401</td>
<td>False-negative rate</td>
</tr>
<tr>
<td>LN Positive</td>
<td>LN Negative</td>
<td>Algorithm</td>
<td>Calculation</td>
<td>Result</td>
</tr>
<tr>
<td>Algorithm positive</td>
<td>53</td>
<td>0</td>
<td>53</td>
<td>Sensitivity</td>
</tr>
<tr>
<td>Algorithm negative</td>
<td>1</td>
<td>420</td>
<td>421</td>
<td>Negative predictive value</td>
</tr>
<tr>
<td></td>
<td>54</td>
<td>420</td>
<td>474</td>
<td>False-negative rate</td>
</tr>
</tbody>
</table>

LN, Lymph node; SLN, sentinel lymph node.

oncology regarding the biological significance of isolated tumor cells in SLNs and whether they should be treated as metastatic nodes in endometrial cancer. The preliminary data suggest that treated patients with isolated tumor cells who received adjuvant therapy, including chemotherapy, do as well as those with node-negative disease; however, untreated observational cohorts with isolated tumor cells and long-term follow-up are lacking. In addition, cytokeratin-positive cells are noted if only single, rare cytokeratin-positive stained cells are present with immunohistochemical staining but are not seen with H&E staining. SLNs containing only cytokeratin-positive cells are considered negative lymph nodes (Tables 10.2 and 10.3).

FIG. 10.9 The endometrial cancer sentinel lymph node (SLN) ultrastaging algorithm used at Memorial Sloan Kettering Cancer Center. H&E, hematoxylin and eosin. (From Kim CH, Soslow RA, Park KJ, et al. Pathologic ultrastaging improves micrometastasis detection in sentinel lymph nodes during endometrial cancer staging. *Int J Gynecol Cancer.* 2013;23(5):964–970.)

TABLE 10.2 Incidence of H&E Macrometastases in Sentinel Lymph Nodes by Final Histologic Grade and Depth of Myometrial Invasion

<table>
<thead>
<tr>
<th>DMI</th>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Grade 3</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>H&amp;E 0</td>
<td>H&amp;E 1</td>
<td>H&amp;E 1</td>
<td>2/242 = 0.8%</td>
</tr>
<tr>
<td>No invasion</td>
<td>n = 165</td>
<td>n = 39</td>
<td>n = 38</td>
<td></td>
</tr>
<tr>
<td>Invasion &lt;50%</td>
<td>H&amp;E 6</td>
<td>H&amp;E 4</td>
<td>H&amp;E 6</td>
<td>16/198 = 8.1%</td>
</tr>
<tr>
<td>n = 80</td>
<td>n = 62</td>
<td>n = 56</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Invasion ≥50%</td>
<td>H&amp;E 6</td>
<td>H&amp;E 3</td>
<td>H&amp;E 8</td>
<td>17/68 = 25.0%</td>
</tr>
<tr>
<td>n = 16</td>
<td>n = 15</td>
<td>n = 37</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>12/261 = 4.6%</td>
<td>8/116 = 6.9%</td>
<td>15/131 = 11.5%</td>
<td>35/508 = 6.9%</td>
</tr>
</tbody>
</table>

DMI, Depth of myometrial invasion; H&E, hematoxylin and eosin.
Table 10.3 Incidence of Ultrastage-Detected, Low-Volume Metastases in Sentinel Lymph Nodes by Final Histologic Grade and Depth of Myometrial Invasion

<table>
<thead>
<tr>
<th>DMI</th>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Grade 3</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No invasion</td>
<td>MM 1</td>
<td>MM 0</td>
<td>MM 0</td>
<td>2/245</td>
</tr>
<tr>
<td></td>
<td>ITC 1</td>
<td>ITC 0</td>
<td>ITC 0</td>
<td>= 0.8%</td>
</tr>
<tr>
<td></td>
<td>n = 165</td>
<td>n = 39</td>
<td>n = 38</td>
<td></td>
</tr>
<tr>
<td>Invasion &lt;50%</td>
<td>MM 2</td>
<td>MM 0</td>
<td>MM 0</td>
<td>16/198</td>
</tr>
<tr>
<td></td>
<td>ITC 4</td>
<td>ITC 4</td>
<td>ITC 6</td>
<td>= 8.0%</td>
</tr>
<tr>
<td></td>
<td>n = 80</td>
<td>n = 62</td>
<td>n = 56</td>
<td></td>
</tr>
<tr>
<td>Invasion ≥50%</td>
<td>MM 0</td>
<td>MM 0</td>
<td>MM 1</td>
<td>5/68</td>
</tr>
<tr>
<td></td>
<td>ITC 2</td>
<td>ITC 0</td>
<td>ITC 2</td>
<td>= 7.4%</td>
</tr>
<tr>
<td></td>
<td>n = 16</td>
<td>n = 15</td>
<td>n = 37</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>10/261</td>
<td>4/116</td>
<td>9/131</td>
<td>23/508</td>
</tr>
<tr>
<td></td>
<td>= 3.8%</td>
<td>= 3.4%</td>
<td>= 6.9%</td>
<td>= 4.5%</td>
</tr>
</tbody>
</table>

DMI: Depth of myometrial invasion; ITC, isolated tumor cells; MM, micrometastasis.

Summary

The SLN mapping algorithm is a reasonable staging strategy for apparent uterine confined endometrial cancer. This approach is gradually becoming the standard of care for surgical staging in many gynecologic oncology practices worldwide. The SLN algorithm allows for at least bilateral pelvic nodal assessment on the majority of new cases of endometrial cancer and can be performed with a minimally invasive approach using near infrared imaging where the technology is available. As our understanding of pathologic biomarkers and the most appropriate adjuvant therapy after hysterectomy continues to be refined, the role of nodal assessment for staging will continue to evolve.

References


Background
The current standard of care for advanced epithelial ovarian cancer (AEOC) is a combination of cytoreductive surgery and paclitaxel and platinum-based chemotherapy. The size of residual disease has been repeatedly proven to be a crucial prognostic factor for affected patients, and the achievement of complete gross tumor resection is now recognized as the main goal of cytoreductive surgery. In a meta-analysis by Chang and colleagues, the authors sought to quantify the impact of complete cytoreduction to no gross residual disease on overall survival among patients with advanced-stage ovarian cancer. A total of 13,257 patients were included in the analysis. The authors found that after controlling for other factors with multiple linear regression analysis, each 10% increase in the proportion of patients undergoing complete cytoreduction to no gross residual disease was associated with a significant and independent 2.3-month increase in median survival compared with a 1.8-month increase in cohort median survival for optimal cytoreduction (residual disease <1 cm).

It has also been previously shown that optimal cytoreduction (≤1 cm residual disease) may be achieved in up to 71% of patients.

Several factors may lead to a suboptimal primary cytoreduction. These include poor patient selection, lack of surgeon expertise in radical abdominal and pelvic surgery, lack of availability of consultants to achieve complete tumor resection, and failure to accept the principle that optimal cytoreduction may offer an advantage to patients in terms of oncologic outcomes. Another important factor when considering the impact of the initial surgical approach is the fact that the rate of complications after up-front surgery is not insignificant. This is of relevance, given that one should aim to minimize exposure of the patient to such complications if there is not going to be a benefit derived from the operation. Therefore it is imperative to identify tools that will ultimately allow surgeons to obtain the information required to make an adequate decision regarding which patients are ideal candidates for surgical treatment and which are ideal candidates for neoadjuvant chemotherapy.

Imaging Tools for Preoperative Evaluation
A number of variables have been previously used to determine when to proceed with primary cytoreduction. These include computed tomography (CT) scans, serum CA-125 levels, and overall patient performance status.

Serum Biomarkers
The most frequently used serum biomarker for ovarian cancer is CA-125. In prior studies it was proposed as a predictor of suboptimal cytoreduction. In a publication by Chi and colleagues, the investigators evaluated 100 consecutive patients with stage III ovarian cancer. Optimal cytoreduction (≤1 cm) was achieved in 73% of patients with a CA-125 level below 500 U/mL, compared with only 22% of those with a CA-125 level above 500 U/mL (P < .001). In a subsequent study, the same investigators reported evaluating preoperative CA-125 levels as a predictor of outcome of primary debulking surgery incorporating the element of upper abdominal surgery. In that study, the authors found that 25% of patients had R0 resection, 55% had residual cancer less than 1 cm, and 20% had residual cancer larger than 1 cm. They concluded that there was no threshold CA-125 level that accurately predicted cytoreductive outcomes. A subsequent meta-analysis by Kang and colleagues evaluated 14 studies with 2192 patients to assess the performance of CA-125 at various cutoff levels as a predictor of the outcome of a cytoreductive surgical procedure. The authors found that preoperative serum CA-125 level higher than 500 U/mL was strongly associated with suboptimal cytoreduction.

Preoperative Imaging Modalities
The most commonly used imaging modality when evaluating patients with advanced-stage ovarian cancer is CT. Several models have been proposed, and these are reviewed in Table 11.1. Nelson and colleagues scored CT scans, on the basis of criteria presented in Table 11.1, as cytoreducible (no disease remaining in criteria site) or not cytoreducible (at least one site of disease remaining) by standard surgical techniques. Optimal cytoreduction was defined as less than 2 cm, and this was achieved in 23 of 24 patients with disease scored as cytoreducible and in
TABLE 11.1 Computed Tomography (CT)-Based Models to Predict Likelihood of Optimal Cytoreduction in Advanced Ovarian Cancer

<table>
<thead>
<tr>
<th>Model</th>
<th>CT Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nelson⁹</td>
<td>Attachment of the omentum to the spleen Disease ≥2 cm in: Mesentery Liver surface or parenchyma Diaphragm Gallbladder fossa Suprarenal paraaortic nodes Pericardial nodes Pulmonary or pleural nodules</td>
</tr>
<tr>
<td>Bristow¹⁰</td>
<td>2 points for each of the following: Peritoneal thickening Peritoneal implants ≥2 cm Small bowel mesentery disease ≥2 cm Large bowel mesentery disease ≥2 cm Omental disease extension to the stomach, spleen, or lesser sac Extension to pelvic sidewall, parametria, or hydroureter Large-volume ascites (seen on all cuts) Suprarenal paraaortic lymph nodes ≥1 cm</td>
</tr>
<tr>
<td>Dowdy¹¹</td>
<td>1 point for each of the following: Diaphragm or lung disease ≥2 cm or confluent plaque Inguinal canal disease or lymph nodes ≥2 cm Liver lesion ≥2 cm on surface or parenchymal lesion of any size Portahepatic or gallbladder fossa disease ≥1 cm Infrarenal paraaortic lymph nodes ≥2 cm</td>
</tr>
</tbody>
</table>

6 of 18 patients with disease scored as not cytoreducible. The authors noted that the CT scans predicted surgical outcome with a sensitivity of 92.3% and a specificity of 79.3%. A subsequent study by Bristow and colleagues¹⁰ proposed another CT-based predictive model. Thirteen radiographic features met the inclusion criteria and were assigned 1 or 2 points, and a Gynecologic Oncology Group performance status score of 2 or higher (assigned 2 points) was used to calculate a predictive index score. The authors reported that a predictive index score of 4 or higher had the highest overall accuracy, at 92.7%, and identified patients undergoing suboptimal cytoreduction with a sensitivity of 100%. Later, Dowdy and colleagues¹¹ published a retrospective analysis reviewing 87 preoperative CT scans for 17 criteria that outlined extent of disease. In that study, the authors found that a model based on diffuse peritoneal thickening and ascites had a 68% positive predictive value and 52% sensitivity and was associated with a low rate of optimal cytoreduction (32%).

Combination Predictive Models

More recently, a number of investigators have explored whether a multimodality evaluation of patients with advanced ovarian cancer can predict no gross residual disease with a high level of accuracy. In a recent study by Suidan and colleagues,¹² the authors sought to assess the ability of preoperative CT scans and CA-125 to predict no gross residual disease at primary cytoreduction in advanced ovarian cancer. That study was a secondary post hoc analysis of a previously published prospective, nonrandomized, multicenter trial that had identified nine criteria for suboptimal (>1 cm residual) disease. Four clinical and 18 radiologic criteria were assessed, and a multivariate model predictive of residual disease was developed. The investigators found that on multivariate analysis, three clinical and eight radiologic criteria were significantly associated with the presence of any residual disease: age 60 years or older (odds ratio [OR], 1.5); CA-125 level 600 U/mL or higher (OR, 1.3); American Society of Anesthesiologists (ASA) classification category 3 or 4 (OR, 1.6); lesions in the root of the superior mesenteric artery (OR, 4.1); splenic hilum or ligaments (OR, 1.4), lesser sac greater than 1 cm (OR, 2.2), gastrohepatic ligament or porta hepatitis (OR, 1.4), gallbladder fossa or intersegmental fissure (OR, 2); suprarenal retroperitoneal lymph nodes (OR, 1.3); small bowel adhesions or thickening (OR, 1.1); and moderate to severe ascites (OR, 2.2). All ORs were significant (P < .01). A predictive score was assigned to each criterion based on its multivariate OR, and the rate of having any residual disease for patients who had a score of 0 to 2, 3 to 5, 6 to 8, or 9 or higher was 45%, 68%, 87%, 96%, respectively. This study demonstrated a predictive model of 11 criteria that were associated with residual disease. In other words, this was a predictive model in which the rate of having any residual disease was directly proportional to a predictive score.

Another potential imaging modality of patients with advanced ovarian cancer is the combination of contrast-enhanced diffusion-weighted magnetic resonance imaging (DW-MRI). Recently, a group of investigators evaluated DW-MRI for staging and assessing operability compared with CT and positron emission tomography–computed tomography (PET-CT) in patients with suspected ovarian cancer. The authors found that DW-MRI showed 94% accuracy for primary tumor characteristics compared with 88% for CT and 94% for PET-CT. DW-MRI showed a higher accuracy of 91% for peritoneal staging compared with CT (75%) and PET-CT (71%). The authors concluded that DW-MRI showed high accuracy for characterizing primary tumors and peritoneal and distant staging compared with CT and PET-CT.¹³

Despite numerous predictive clinical, radiologic, or serologic variables, there are no conclusive models that provide objective and accurate measures that serve as predictors of microscopic residual disease. In addition, it has been challenging to demonstrate consistent reproducibility of such models outside of the institutions that have created such models. In addition, there is a significant element of variability regarding the surgical aggressiveness in the respective institutions where such models originate.

Rationale for Laparoscopic Evaluation

A laparoscopic evaluation of the abdomen and pelvis to determine whether the tumor volume is resectable might offer surgeons an additional tool helping them decide who is a good candidate for up-front cytoreduction. In addition, the laparoscopic approach allows for a fast recovery of the patient, so that if it is decided not to proceed with an attempt at initial
cytoreduction, the patient will then be able to undergo treatment in the form of systemic chemotherapy much sooner. The laparoscopic approach offers excellent visualization of all quadrants of the abdomen and pelvis. In addition, it allows for tissue biopsy for definitive diagnosis and molecular analysis. This access to tissue analysis may allow patients to be involved in innovative trials known as window-of-opportunity trials (WOTs). This provides for an evaluation of the clinical and molecular impact of novel therapeutic agents among those triaged to primary cytoreductive surgery. Lastly, the tumor collected at the time of interval cytoreductive surgery can be evaluated for the impact of novel combinations of neoadjuvant therapeutic agents.

**History of Laparoscopy to Assess Feasibility of Cytoreduction**

Various scores have been proposed, but only one has been uniformly validated and adopted. In 2005, Fagotti and colleagues reported on 65 patients who underwent preoperative clinical-radiologic evaluation followed by laparoscopy and then laparotomy. The investigators evaluated for several elements, including ovarian masses (unilateral vs. bilateral), omental cake or nodules, peritoneal and diaphragmatic carcinomatosis, mesenteric retraction, bowel and stomach infiltration, liver metastases, and bulky lymph nodes. In that study, optimal debulking was achieved in 87% of patients whose disease was deemed resectable on the basis of laparoscopy findings. The overall accuracy rate of laparoscopy in predicting optimal cytoreduction was 90%. In 2006, the same group proposed a laparoscopy-based predictive index value (PIV) based on objective parameters determined at pre-cytoreduction laparoscopy. The findings at laparoscopy were used to estimate the chances of optimal cytoreduction (residual disease ≤1 cm) (Table 11.2). The scores for each item were added to obtain an overall score, the PIV. The authors in that study found that the overall accuracy of the model in predicting surgical outcome was approximately 75% and also that if the PIV was 8 or higher, then the likelihood that a patient would have a suboptimal surgical result was 100%. This was a landmark study because it showed that for the first time laparoscopy rather than imaging studies could predict with excellent accuracy the chance of an optimal cytoreduction.

In 2011, Fagotti and her group performed a prospective evaluation of the learning curve for surgeons determining the PIV. The authors compared the scores for each laparoscopic parameter assigned by fellows and senior surgeons. Ninety consecutive women with suspected advanced ovarian or peritoneal cancer underwent laparoscopy performed by a fellow and senior surgeon sequentially with independent assignment of scores for disease distribution. The median PIV was 6 (range, 0–10) for the fellows and 6 (range, 0–14) for the senior surgeons. The authors concluded that fellows in gynecologic oncology with at least 12 months’ experience assigned laparoscopy-based scores similar to those of senior surgeons.

Subsequently, Fagotti and colleagues evaluated the reproducibility of a laparoscopic assessment before cytoreductive surgery. They performed a prospective, multicenter trial (Olympia-MITO 13) in which the laparoscopy-based PIV was evaluated in 10 satellite centers. A total of 120 patients with advanced ovarian, fallopian tube, or primary peritoneal cancer underwent laparoscopy at the satellite centers; the procedures were recorded and blindly reviewed at the coordinator center. The investigators reported an accuracy rate of 80% or greater in 9 of 10 satellite centers.

The original studies on the evaluation of a laparoscopic approach with regard to feasibility of cytoreduction were all based and designed on a definition of optimal residual disease as 1 cm or less. However, in subsequent years the routine use of radical upper abdominal surgical procedures during cytoreductive surgery has significantly increased the chance of achieving complete tumor debulking to microscopic residual disease. To this end, efforts were made to ensure that laparoscopy was still a useful tool in assessing the abdomen and pelvis as a predictor of optimal disease. A subsequent proposal was made

**TABLE 11.2** Laparoscopic Features and Corresponding Score for Tumor Volume Assessment

<table>
<thead>
<tr>
<th>Laparoscopic Feature</th>
<th>Score 0</th>
<th>Score 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peritoneal carcinomatosis</td>
<td>Carcinomatosis involving a limited area (along the paracolic gutter or the pelvic peritoneum) and surgically removable by peritonectomy</td>
<td>Unresectable massive peritoneal involvement as well as with a miliary pattern of distribution</td>
</tr>
<tr>
<td>Diaphragmatic disease</td>
<td>No infiltrating carcinomatosis and no nodules confluent in most of the diaphragmatic surface</td>
<td>Widespread infiltrating carcinomatosis or nodules confluent in most of the diaphragmatic surface</td>
</tr>
<tr>
<td>Mesenteric disease</td>
<td>No large infiltrating nodules and no involvement of the root of the mesentery as would be indicated by limited movement of the various intestinal segments</td>
<td>Large infiltrating nodules or involvement of the root of the mesentery indicated by limited movement of the various intestinal segments</td>
</tr>
<tr>
<td>Omental disease</td>
<td>No tumor diffusion observed along the omentum up to the large stomach curvature</td>
<td>Tumor diffusion observed along the omentum up to the large stomach curvature</td>
</tr>
<tr>
<td>Bowel infiltration</td>
<td>No bowel resection was assumed and no miliary carcinomatosis on the serosa observed</td>
<td>Bowel resection assumed or miliary carcinomatosis on the serosa observed</td>
</tr>
<tr>
<td>Stomach infiltration</td>
<td>No obvious neoplastic involvement of the gastric wall</td>
<td>Obvious neoplastic involvement of the gastric wall</td>
</tr>
<tr>
<td>Liver metastases</td>
<td>No surface lesion</td>
<td>Any surface lesion</td>
</tr>
</tbody>
</table>
wherein mesenteric retraction and miliary carcinomatosis on the serosa of the small bowel were removed from the scoring system. In their study, Petrillo and colleagues sought to update their previous laparoscopy-based model to predict incomplete cytoreduction (residual disease >0) in advanced ovarian cancer after the introduction of upper abdominal surgery. All patients underwent a laparotomy after diagnostic laparoscopy. The presence of omental cake; peritoneal extensive carcinomatosis; diaphragmatic confluent carcinomatosis; bowel infiltration; stomach, spleen, and/or lesser omentum infiltration; and superficial liver metastases was evaluated. No gross residual disease was achieved in 58% of patients. Upper abdominal surgery was required in 53.3% of cases. The authors noted a very high overall agreement between laparoscopy and laparotomic findings, which ranged from 74.7% for omental cake to 94.8% for stomach infiltration. At a laparoscopic PIV of 10 or higher, the chance of achieving complete primary debulking with a surgical procedure was 0, and the risk of unnecessary laparotomy was 33.2%. This new model led to the proposal that a PIV of 10 or higher should be the new determinant to proceed with neoadjuvant chemotherapy, rather than 8 or higher.

### Indications for Laparoscopic Evaluation
The most common indication for a laparoscopic evaluation of the abdomen and pelvis before cytoreduction is performed in the up-front setting. In other words, this is usually performed at the time of initial diagnosis. However, a laparoscopic assessment for feasibility of cytoreduction may also be considered in the setting of interval cytoreduction and in select cases of recurrent disease.

Diagnostic laparoscopy with PIV should be considered in most women with suspected advanced ovarian cancer, as evidenced by the presence of ascites, carcinomatosis, and/or elevated serum CA-125. In general, patients with multiple medical comorbidities not considered ideal candidates for a surgical procedure would not be considered candidates for the diagnostic laparoscopy, and in these patients an image-guided biopsy is performed to establish the diagnosis and subsequently proceed with neoadjuvant chemotherapy. In addition, patients who would otherwise not benefit from cytoreductive surgery—in other words, those with parenchymal liver disease, unresectable lung disease, or distant metastases—would also not be considered ideal candidates for laparoscopic assessment and thus would be candidates for diagnostic biopsy and subsequent chemotherapy (Fig. 11.1).

### Method of Laparoscopic Assessment
The PIV or Fagotti score is a scoring system based on the evaluation of six features assessed through a laparoscopic exploration of the abdomen and pelvis. When the laparoscopic variables, as described in Table 11.2, are found, a score of 2 is assigned, and when such findings are absent a score of 0 is assigned. After a complete exploration, the sum of all parameters designates a final score that will range from 0 to 14.

It is imperative that the evaluation of each parameter not be misinterpreted with regard to whether the disease at that site is resectable or not, solely by its nature. The PIV is meant to provide a composite score that will then be used to determine whether a patient should undergo cytoreductive surgery or neoadjuvant chemotherapy.

In most centers a single surgeon may perform the laparoscopic assessment and therefore assign a PIV to the patient. However, there are centers in which a two-surgeon team is used to independently assign a PIV. This is done with the purpose of ensuring that certain elements of individual bias toward either surgical intervention or chemotherapy are removed from the assessment. In those centers, when there is a discrepancy between the two surgeons, a third surgeon is used as a tiebreaker to determine the final recommendation for the management of the patient. The features evaluated are described in the following sections.

### Parietal Peritoneum
A score of 2 is assigned when there is evidence of unresectable massive peritoneal involvement or miliary pattern of distribution. However, if there is carcinomatosis limited to one area of the abdominal or pelvic cavity, along the paracolic gutter or the pelvic peritoneum, a score of 0 should be assigned (Fig. 11.2).

### Diaphragmatic Disease
A score of 2 should be assigned in the presence of widespread bilateral infiltrating carcinomatosis, or confluent nodules to most of the diaphragmatic surface including the central portion. Although diffuse diaphragmatic disease may potentially be resectable, there is evidence that diaphragmatic involvement has a significant association (23.5%–73% in patients with pleural effusion) with penetrating disease that may potentially involve the thoracic cavity. When these findings are not present in the diaphragm, then a score of 0 is assigned (Fig. 11.3).

### Omentum
A score of 2 is assigned when there is evidence of confluent tumor diffusion observed along the omentum up to the large curvature of the stomach. When these findings are absent, a score of 0 is assigned. It should be noted that presence of a single or discrete lesions, even larger than 5 cm, is not adequate for a score of 2 (Fig. 11.4).
Chapter 11 Indications for Laparoscopic Assessment of Cytoreduction

Bowel Infiltration

A score of 2 is assigned when a bowel resection will be required or when there is evidence of miliary carcinomatosis. Of note, rectosigmoid resection is excluded because this is a commonly performed procedure to remove pelvic disease and posterior exenteration is considered a standard surgical procedure in patients with advanced ovarian cancer. When these findings are not seen, then a score of 0 is assigned (Fig. 11.5).

Stomach, Spleen, and Lesser Omentum

A score of 2 is assigned when there is obvious neoplastic involvement of the gastric wall, spleen, and/or lesser omentum. Similarly, a score of 2 is assigned when there is evidence of omental involvement extending to and including the greater curvature of the stomach. In addition, if a patient has evidence of disease at the hilum of the spleen, this would also be considered grounds for a score of 2 (Fig. 11.6).

Liver Metastases

A score of 2 is assigned if there is evidence of superficial liver lesions larger than 2 cm. However, it is important to note that when there is evidence of intraparenchymal liver disease or disease localized deep in the intersegmental fissures of the liver, laparoscopy may not be the ideal tool to evaluate such disease. Thus it is recommended that all patients undergo preoperative evaluation with CT scans of the abdomen and pelvis to ensure that the liver is adequately evaluated. When there are no surface lesions in the liver, a score of 0 is assigned (Fig. 11.7).

Technique for Laparoscopic Assessment

The standard approach to laparoscopic assessment of optimal cytoreduction consists of a transumbilical trocar insertion for the camera and at least two ancillary ports for the instruments.
(Fig. 11.8). It is generally recommended that the primary trocar be inserted by means of an open technique to avoid injury to the underlying structures. This is particularly relevant given that bulky tumor or carcinomatosis may predispose the bowel or other structures to become densely adherent to the anterior abdominal wall. If there is large bulky disease in the upper abdomen, one may consider evaluating the abdominal entry approach through the use of transabdominal ultrasound to find a safe location for first trocar insertion.

Ascites, if present, must be drained to allow an easy and reliable evaluation of the laparoscopic variables. Lysis of adhesions, when possible, should be performed to make the laparoscopic evaluation as complete as possible. The evaluation should start from the upper abdomen with the patient in reverse Trendelenburg position. Evaluation of the rest of the abdomen and pelvis should require steep Trendelenburg position. Once a cumulative score has been determined and confirmed, the patient should be triaged to the most suitable therapeutic option. If a complete primary debulking procedure is not feasible (score ≥10), a sample of tissue must be collected. Before removal of the trocars, all the residual gas should be removed and the peritoneal entrance of the trocar checked for possible bleeding.

The risk of port-site metastasis has already been shown to be a minimal concern in the setting of gynecologic cancers. However, when present, these are usually noted when there is evidence of metastatic carcinomatosis. To prevent or decrease the likelihood of port-site metastases, one may elect to deflate the abdomen before removal of all trocars and then to irrigate the port sites with 5% povidone-iodine solution. In addition, the peritoneum and fascia for all 12-mm trocars are closed at the end of each operation.

**FIG. 11.5** (A) No bowel resection required and no carcinomatosis on bowel surface. (B) Miliary carcinomatosis.

**FIG. 11.6** (A) No obvious neoplasm in gastric wall. (B) Obvious disease in gastric wall.

**FIG. 11.7** (A) No surface lesions noted. (B) Any surface lesion of carcinomatosis.
Incomplete Evaluation
The appropriate evaluation of the abdomen and pelvis requires that six parameters be assessed. However, it is not uncommon for patients with advanced ovarian cancers to have a number of factors that may impede such thorough evaluation. Among these, the most common include extensive distribution of intraabdominal disease, adhesions, challenging patient body habitus, or history of previous surgery. In these cases, one may elect to request the anesthesiologist to change the position of the surgical table or one may insert additional trocars, enabling placement of the camera through different trocars to achieve adequate visualization of the abdomen and pelvis. When one is unable to determine the score for a specific parameter but the area of interest is not accessible, some advocate assigning a score of 0, thus avoiding the risk that patients with potentially resectable disease are not explored. However, this remains a topic of debate, because others feel that if an area is not accessible, it should be assigned a score of 2. In such cases, best clinical judgment should be used in determining whether to proceed with a primary debulking surgical procedure or neoadjuvant chemotherapy.

Clinical Implications
One of the principal elements of introducing a novel strategy for evaluation of surgical resection is to determine if ultimately such an approach will affect patient survival and overall oncologic outcomes. In a study by Vizzielli and colleagues, the investigators sought to determine whether laparoscopic evaluation of intraperitoneal diffusion of disease at the time of primary debulking operation, assessed through a scoring system (PIV), might have an independent impact on survival in a large, single-institution series. In that study, a total of 348 consecutive patients were included. Women were stratified into three different groups: high tumor load (HTL) for PIV of 8 or higher, intermediate tumor load (ITL) for PIV equal to 6 or 4, and low tumor load (LTL) for PIV of less than 4. When stratifying the population according to laparoscopic tumor load, the median progression-free survival was 33 months for LTL, 18 months for ITL, and 14 months for HTL (P = .0001). The median overall survival with respect to laparoscopic PIV was not reached for LTL, whereas it was 47 months for ITL, and 33 for HTL, respectively (P = .0001). The predictive value of the PIV score was maintained even in multivariate analysis together with residual disease. The authors concluded that residual disease remains an important prognostic factor in patients with advanced ovarian cancer but that tumor dissemination plays a role in determining prognosis.

Another important clinical application of the laparoscopic score is its ability to predict major postoperative complications after a primary debulking surgical procedure. In a study of 555 patients, the investigators noted that the major complication rate was 18.3%. They also found that significant predictors of major complications were poor performance status, presence of ascites (>500 mL), serum CA-125 level higher than 1000 U/mL, and high laparoscopic tumor load (PIV ≥8). The mean risk of developing major postoperative complications was 3.7% in patients with score 0 to 2, 13.2% in patients with score 3 to 5, and 37.1% in patients with score 6 to 8 (Tables 11.3 and 11.4). In the validation population, the predicted risk of major complications was 17.8% versus 16.7% observed risk. The authors concluded that the PIV could accurately predict a patient’s postoperative outcome.

Table 11.3: Predictive Score of Major Postoperative Complications

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Risk Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECOG PS</td>
<td></td>
</tr>
<tr>
<td>≤2</td>
<td>0</td>
</tr>
<tr>
<td>&gt;2</td>
<td>1</td>
</tr>
<tr>
<td>Ascites (≤500 cm³)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>0</td>
</tr>
<tr>
<td>No</td>
<td>1</td>
</tr>
<tr>
<td>CA-125</td>
<td></td>
</tr>
<tr>
<td>≤1000 U/mL</td>
<td>0</td>
</tr>
<tr>
<td>&gt;1000 U/mL</td>
<td>1</td>
</tr>
<tr>
<td>Tumor Load</td>
<td></td>
</tr>
<tr>
<td>Low (PIV 0–2)</td>
<td>0</td>
</tr>
<tr>
<td>Intermediate (PIV 4–6)</td>
<td>2</td>
</tr>
<tr>
<td>High (PIV &gt;8)</td>
<td>5</td>
</tr>
</tbody>
</table>

ECOG PS, Eastern Cooperative Oncology Group performance status; PIV, predictive index value.

Table 11.4: Prediction of Risk of Major Complications Using the Score as Progressive Values

<table>
<thead>
<tr>
<th>Overall Risk Score</th>
<th>Complication Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2.2</td>
</tr>
<tr>
<td>1</td>
<td>3.5</td>
</tr>
<tr>
<td>2</td>
<td>5.4</td>
</tr>
<tr>
<td>3</td>
<td>8.4</td>
</tr>
<tr>
<td>4</td>
<td>12.7</td>
</tr>
<tr>
<td>5</td>
<td>18.7</td>
</tr>
<tr>
<td>6</td>
<td>26.7</td>
</tr>
<tr>
<td>7</td>
<td>36.7</td>
</tr>
<tr>
<td>8</td>
<td>47.9</td>
</tr>
</tbody>
</table>

Laparoscopic Evaluation at Interval Cytoreductive Surgery
In patients who undergo neoadjuvant chemotherapy, it is also important to consider whether those patients are candidates for...
optimal surgery after three or six cycles of such treatment. The routine assessment for response to therapy at that time generally relies on CT scan evaluation and serum CA-125 level. However, laparoscopy may also offer an added advantage in this setting in order to assess the likelihood of no gross residual disease at that time.

One of the first studies evaluating the role of laparoscopy before interval debulking surgery was published by Fagotti and colleagues in 2010.23 In that study, a total of 111 patients with advanced ovarian cancer underwent neoadjuvant chemotherapy, and all patients were evaluated for radiologic and serologic response before interval surgery. The authors found that with performance of laparoscopy, the rate of unnecessary exploratory laparotomy was decreased from 30% to 13%. The authors found that the most appropriate cutoff value to predict optimal residual disease after surgery was a PIV lower than 4.

**Prosp ective Trial Results**

The overwhelming majority of the data that have been published on the role of laparoscopy in patients with advanced ovarian cancer have been of a retrospective nature. However, there are a number of very important prospective trials that should be highlighted.

The SCORPION (Surgical Complications Related to Primary or Interval Debubking in Ovarian Neoplasm) trial NCT01461850 aimed to evaluate and compare the surgical complications of primary surgery and interval debulking surgery.24 This trial involved patients with advanced ovarian cancer with a PIV score of 8 through 12. Patients were randomly assigned (1:1 randomization) to undergo either a primary debulking procedure followed by systemic adjuvant chemotherapy (group A) or neoadjuvant chemotherapy followed by interval debulking surgery (group B). The authors found that 53% of patients in group A experienced early grade III to IV complications versus 5.7% in group B (P = .0001). They also showed that quality-of-life scores were more favorable in group B than in group A in patients with HTL.

In a recent study by Rutten and colleagues,25 the authors investigated whether initial diagnostic laparoscopy could prevent futile primary cytoreductive surgery by identifying patients with advanced-stage ovarian cancer in whom more than 1 cm of residual disease was left after such a procedure. This was a multicenter, randomized controlled trial within eight gynecologic cancer centers in the Netherlands. Participants were randomly assigned to undergo either laparoscopy or a primary debulking operation. A total of 201 patients were included in the analysis. The authors found that futile laparotomy occurred in 10% of patients in the laparoscopy group versus 39% of patients in the primary surgery group (P < .001). The investigators concluded that laparoscopy reduced the number of futile laparotomies.

**Summary**

The laparoscopic assessment of patients with advanced ovarian cancer has been shown to be safe and feasible. In addition, there is vast evidence in the literature that this tool is not only reproducible but also may provide an objective evaluation, helping to determine ideal candidates for primary debulking surgery versus neoadjuvant chemotherapy.

Moreover, it provides a tool that not only helps in obtaining tissue for diagnosis but also enables collection of valuable samples for molecular analysis and testing of novel therapeutics and targeted therapies.

**References**


The prognostic implications associated with the resection of all visible residual disease in patients with advanced-stage ovarian cancer have been clearly established in several retrospective and nonrandomized prospective studies. In 2013, Landrum and colleagues detailed the survival outcomes of patients with no visible residual disease treated with intraperitoneal chemotherapy, reporting a median overall survival of 110 months. Several other authors have also validated these findings.

Over the past decade, improved surgical techniques have resulted in higher rates of total macroscopic tumor clearance. The incorporation of what is commonly referred to as “radical upper abdominal surgery,” inclusive of diaphragm peritonectomy, splenectomy, and hepatic resections or ablative procedures, has been shown to increase the rates of complete tumor resection.

Advanced-stage ovarian cancer frequently involves upper abdominal structures, including the liver, diaphragm, and spleen. This disease distribution is not unexpected, given the physiologic distribution of peritoneal fluid, traveling in a clockwise manner along the right paracolic gutter to the right upper quadrant (RUQ) secondary to bowel peristalsis and diaphragmatic excursion with respiration. As many as 40% of patients with advanced-stage ovarian cancer have bulky tumor on the diaphragm. More specifically, diaphragmatic tumors are frequently identified in the region where the diaphragm peritoneum is reflected onto the posterior aspect of the right lobe of the liver, commonly adherent to and involving both the diaphragmatic and liver surfaces (Morrison pouch, hepatorenal recess). This marks the most dependent portion of the abdominal cavity in the supine position.

Furthermore, preoperative radiographic imaging may indicate involvement of the liver parenchyma, gallbladder, and porta hepatitis. These locations may also harbor recurrent, malignant lesions, necessitating resection at the time of secondary surgical cytoreduction in appropriately selected patients.

In addition to the RUQ, the left upper quadrant (LUQ) of the abdomen is reportedly involved with metastatic disease in up to 60% of patients with advanced-stage ovarian cancer. The anatomic relationships among the greater omentum, transverse colon, stomach, spleen, and left hemidiaphragm predispose patients to tumor involvement by contiguous extension.

Less commonly, metastatic deposits may involve the stomach, splenic hilum, and left diaphragm independently.

Those critical of aggressive upper abdominal surgical resection have implied that upper abdominal disease burden is reflective of disease biology and negatively affects survival independently of surgical outcome. Conversely, published reports demonstrate that extensive upper abdominal resections required to achieve minimal residual disease are associated with extended long-term survival, and thus operative efforts should not be abbreviated because of metastatic disease present in this anatomic region.

Nevertheless, ovarian cancer metastases involving the liver, diaphragm, and spleen are frequently cited as impediments to achieving complete cytoreduction. Safe and effective operative and perioperative management of such disease requires that the surgeons responsible for managing disease in the upper quadrants of the abdomen be familiar with the regional anatomy and be proficient in both excisional and ablative techniques, allowing for complete surgical resection. The use of a multidisciplinary ovarian cancer surgical team, combined with developments in technology and instrumentation, has facilitated the inclusion of extensive upper abdominal procedures to achieve complete surgical cytoreduction in many patients. This chapter presents the relevant anatomy and surgical methods required for a proactive approach to cytoreduction in the upper quadrants, including the liver, diaphragm, and spleen.

**Anatomic Considerations**

**Liver**

The liver lies anatomically below the surface of the diaphragm in the RUQ of the abdominal cavity and is the largest gland in the female body, with a weight of approximately 1500 g. The gallbladder is adherent to the ventral surface of the liver and divides the right and left hemilivers, with the base of the liver oriented to the right and the contralateral apex to the left. The surface of the liver is red-brown, and the organ is enveloped by a layer of visceral peritoneum known as the Glisson capsule. The superior boundary of the liver corresponds to approximately the fifth rib; the inferior margin lies just below the costal margin.
The liver is secured by several ligamentous attachments including the round, falciform, triangular, and coronary ligaments (Fig. 12.1). The round ligament, which is the remnant of the obliterated umbilical vein, enters the liver hilum at the leading edge of the falciform ligament, anchoring the liver to the anterior abdominal wall. The falciform ligament can then be followed to the left and right triangular ligaments, which extend anteriorly, where they are referred to as the coronary ligaments, anchoring the liver to the diaphragm's surface. The right coronary ligament additionally extends to join the peritoneal reflection overlying the right kidney, providing additional retroperitoneal support. It is important to note that, in an analogous fashion to the avascular spaces of the pelvis, these ligaments can be divided in a bloodless manner to facilitate complete mobilization of the right and left hepatic lobes, allowing for surgical resection or ablation, and access to the commonly diseased diaphragm.

The liver is also secured centrally via the gastrohepatic and hepatoduodenal ligaments. The hepatoduodenal ligament is commonly referred to as the porta hepatis and houses the portal vein, hepatic artery, and common bile duct (portal triad). The hepatoduodenal ligament extends from the inferior aspect of the liver surface, to the left of the gallbladder, and attaches to the first and second portions of the duodenum. Immediately dorsal to the hepatoduodenal ligament is the epiploic foramen of Winslow, which can be accessed from the right side of the abdominal cavity, allowing access to the lesser sac. Isolation of the hepatoduodenal ligament facilitates compression of the portal triad, with control of vascular inflow to the liver, also known as the Pringle maneuver. The gastrohepatic ligament is also known as the lesser omentum and represents a double layer of peritoneum that extends from the liver to the lesser curvature of the stomach. The attachment of the lesser omentum to the liver is anterior to the caudate lobe and posterior to the left hemiliver.

Several important anatomic structures lie in close proximity to the liver, and understanding these anatomic relationships is important to the successful completion of a surgical procedure without unintended injury. The hepatic flexure of the transverse colon abuts the right border of the liver, whereas the duodenum is inferior to the liver and covered by the transverse colon and its associated mesentery. In addition, the right kidney and right adrenal gland lie in the right renal fossa, lateral and posterior to the second portion of the duodenum, and can be encountered with lateral dissection and mobilization of the liver in the anatomic region referred to as the Morison pouch.

Physiologically, the liver has several critical functions, including but not limited to storage; metabolism; synthesis of coagulation factors, complement, and proteins; secretion; and detoxification.

![Anatomy of the liver and ligamentous attachments](image-url)
Liver Surface
As mentioned earlier, the liver surface is reddish-brown, smooth, and concave, conforming to the shape of the overlying diaphragm. The ligamentous attachments supporting the liver are in union with the Glisson capsule. The exception to the aforementioned relates to the posterior aspect of the liver, where the bare area lies within the boundaries of the coronary or triangular ligaments. The bare area is unique because the liver is in direct communication with the diaphragm’s surface and the inferior vena cava (IVC) and thus traditionally is spared from involvement by metastatic implant in patients with advanced-stage ovarian cancer.

Liver Segments
Grossly, the liver is divided into the right and left lobes by a plane connecting the gallbladder fossa to the center of the suprahepatic IVC (Cantlie line). The right lobe of the liver typically accounts for approximately 65% of the liver mass, with the left lobe accounting for the remainder. Commonly, the falciform ligament is interpreted as an anatomic demarcation between the right and left lobes of the liver. However, this is incorrect, because the falciform divides the left lateral segment from the left medial segment, with important implications in hepatic resections.

Significant advances in the understanding of liver surgical anatomy were ushered in by the French surgeon and anatomist Couinaud, who divided the liver into eight discrete segments (Fig. 12.2). The segments are numbered in a clockwise fashion, beginning with segment I, or the caudate lobe. The caudate lobe represents the most dorsal portion of the liver and is in juxtaposition to the retrohepatic vena cava. The ligamentum venosum, or the fibrous remnant of the ductus venosus, is a continuation of the round ligament, and tumors along the ligamentum venosum often abut the anterior surface of the caudate lobe in the space between the left portal vein and the left hepatic vein. Segments II and III comprise the left lateral segments, whereas segment IV is the left medial segment. Uniquely, segment IV is further divided into segment IVA, cephalad and below the diaphragm, and segment IVB, caudal to segment IVA and adjacent to the gallbladder fossa. Thus, moving in a clockwise direction, the left lobe of the liver is composed of segments I through IV. Segments V, VI, VII, and VIII comprise the right lobe of the liver, with segments V and VIII referred to as the right anterior lobe and segments VI and VII as the right posterior lobe.

The functional hepatic anatomy is additionally demarcated by established fissures (scissura) defined by Bismuth in 1982, indicating the location of the three hepatic veins. The main fissure contains the middle hepatic vein and represents the anatomic delineation. The left hepatic vein drains the left lateral segments and lies within the left fissure. Last, the right hepatic vein courses long the right fissure and separates the right posterior lateral and right anterior lateral sections. Preservation of these veins is critical during segmental resections in order to avoid unintended congestion and necrosis of adjacent hepatic tissue.

Porta Hepatis
The porta hepatis contains three critical anatomic structures: the common bile duct, portal vein, and hepatic artery proper. The liver has a dual blood supply, receiving blood flow from two distinct sources: the proper hepatic artery and the portal vein. The hepatic artery is responsible for approximately 25% of the total blood supply to the liver, whereas the portal vein accounts for the remaining 75%. The common hepatic artery is a branch of the celiac trunk and courses anterior to the pancreas before giving off the gastroduodenal artery inferiorly, where it then becomes the hepatic artery proper, entering the hilum of the liver via the hepatoduodenal ligament. Within the hepatoduodenal ligament the hepatic artery proper is anterior to the portal vein and lies to the left of the common bile duct. The hepatic artery proper then branches to give rise to the right and left hepatic artery. The right hepatic artery commonly runs posterior to the bile duct before entering the right hemiliver. The cystic artery, supplying the gallbladder, arises from the right hepatic artery in variable locations within the Calot triangle.

There are several anatomic hepatic arterial variants, occurring in nearly 25% of patients, with which surgeons should be familiar before performing operative exploration in the region of the porta hepatis. Most commonly, there is a replacement or accessory right hepatic artery arising from the superior mesenteric artery, or an alternate left hepatic artery arising as a branch from the left gastric artery coursing through the hepatogastric ligament. Rarely seen is a complete replacement of the common hepatic artery arising from the superior mesenteric artery.

The portal vein accounts for approximately 75% of the hepatic blood supply. It is formed as the confluence of the splenic and superior mesenteric veins. The portal vein, in addition, receives nutrient-rich blood from the inferior mesenteric vein, which most commonly drains into the splenic vein. The main portal vein runs posterior to the proper hepatic artery and common bile duct before dividing into the right and left portal veins.

The left portal vein often has a longer extrahepatic course and branches sharply to the left before entering the left lobe of the liver at the umbilical fissure. The left portal vein supplies liver segments I, II, III, and IV. Conversely, the right portal vein is often larger in caliber and shorter, with anatomic variants including intraparenchymal branching. Analogous to the hepatic artery, there is significant anatomic variation of the portal venous anatomy, with 20% to 30% of individuals having portal vein trifurcation.
The flow of bile follows a sequential path from the biliary capillaries to the interlobar bile ducts, which merge to ultimately form the right and left hepatic ducts. The right and left hepatic ducts then come together to form the common hepatic duct, which accepts the cystic duct to become the common bile duct. The common bile duct is anterior within the porta hepatitis and travels posterior to the duodenum, where it joins the pancreatic duct and empties into the second part of the duodenum via the ampulla of Vater.

**Hepatic Veins**

Hepatic venous drainage is accomplished via the right, middle, and left hepatic veins, which course through the liver and drain into the suprahepatic inferior vena cava (IVC). The right hepatic vein traditionally drains directly into the IVC, whereas the middle and left hepatic veins commonly merge to form a short trunk before entering the IVC. The right hepatic vein is responsible for the drainage of liver segments V, VI, VII, and VIII; the middle hepatic vein, segments IV, V, and VIII; and the left hepatic vein, segments II and III. The caudate lobe drains directly into the IVC via short perforating veins.

During the course of liver mobilization, catastrophic bleeding can be encountered secondary to inadvertent injury of these venous structures. Specifically, with mobilization of the right lobe of the liver, care must be taken to identify the right hepatic vein, protecting it from injury or laceration. This can also be seen with undue traction before adequate mobilization. Furthermore, 15% of patients may have an accessory right hepatic vein coursing ventral to the hepatocaval ligament. If concern exists, meticulous dissection and identification of these structures are required during surgical exploration.

**Adjacent Organs at Risk: Stomach, Duodenum, Right Kidney, and Right Adrenal Gland**

The liver and stomach are attached via the hepatogastric ligament. To allow for improved mobilization and exposure, facilitating dissection, oral or nasogastric tube decompression of the stomach can be performed. This can facilitate entry through the hepatogastric ligament, exposing the caudate lobe of the liver.

The duodenum is anatomically adjacent to the head and inferior border of the pancreas and may be encountered during mobilization of the right lobe of the liver and hepatic flexure of the colon and during a paraaortic lymphadenectomy approaching the level of the right renal vein. Thus, the surgeon should be aware of the duodenum’s anatomic location and considerations. The duodenum is approximately 25 cm in length and has four parts. The first part of the duodenum is a continuation of the pylorus and lies within the intraperitoneal compartment. It is attached to the liver via the gastroduodenal ligament. The components of the portal triad are located immediately posterior to the first part of the duodenum. The second part of the duodenum is retroperitoneal and travels parallel to the IVC, anterior to the right kidney, and right renal vessels. It is in close proximity to the right inferior lobe of the liver. The third part of the duodenum travels horizontally across the midline, coursing beneath the superior mesenteric artery. The final, fourth part of the duodenum then travels back into the peritoneal cavity, joining the proximal jejunum, where it is suspended by the ligament of Treitz.

The right kidney is in close anatomic approximation with the hepatic flexure of the colon, the second portion of the duodenum, the right lobe of the liver, and the small bowel. The right adrenal gland rests on the superior border of the right kidney. The right kidney is enveloped in perinephric fat and is covered with a fibroareolar layer termed Gerota fascia that, in addition, encompasses the adrenal gland. The Morison pouch is the peritoneal reflection separating the kidney from the right lobe of the liver and is a common location for metastatic ovarian cancer deposits.

The right renal artery courses inferiorly and travels posterior to the IVC and the right renal vein. The right adrenal gland, typically measuring 4 cm in length and 2 cm in width, is triangular and retroperitoneal and rests above the right kidney. Along with the kidney, it is contained within Gerota fascia. The adrenal glands are among the most vascularized organs in the body, which can result in unanticipated bleeding if they are traumatized during mobilization of the posterior right lobe of the liver. The right adrenal vein, which drains directly into the IVC, is also at risk of injury during hepatic mobilization. The right adrenal tissue is a bright yellow-orange color, helping distinguish it from neighboring adipose tissue.

**Diaphragm**

Anatomically, the diaphragm is a large dome-shaped structure, composed of muscle and fibrous tissue, that separates the thoracic from the abdominal cavities. It plays a principal role in respiration. The thoracic aspect of the diaphragm is in contact with the lung pleura. The contralateral side is lined by the abdominal peritoneum anteriorly and laterally. The mediastinal diaphragmatic surface is retroperitoneal and corresponds to the bare area previously discussed. The right posterior lateral aspect of the abdominal diaphragm is in contact with the right kidney and represents the caudal boundary of Morison pouch. The left posterior lateral aspect is in contact with the spleen via the phrenorenal ligament, which must be transected during splenectomy.

**Muscular Components**

The diaphragm is composed of skeletal muscle and originates from three distinct regions. The sternal, costal, and lumbar components of the diaphragm arise from the xiphoid process, lower six ribs, and diaphragm crura, respectively. The posterior boundary of the diaphragm is composed of the lateral and medial arcuate ligaments, which circumscribe the proximal portions of the quadratus lumborum and psoas muscles, respectively. All the muscular fibers insert into the central tendon of the diaphragm, which is an aponeurosis in the center of the diaphragm (Fig. 12.3).

**Apertures and Visceral Relations**

There are three principal diaphragmatic apertures. The most inferior is the aortic hiatus, which is found at the level of the 12th thoracic vertebra. It lies between the right and left crura of the diaphragm and contains the aorta, azygos vein, and thoracic duct. The esophageal hiatus is at the level of the 10th thoracic vertebral body and is located to the left of the central tendon enveloped by the right crus of the diaphragm. The esophageal hiatus contains the esophagus as well as the anterior and posterior vagal trunks. Lastly, the caval opening is at the level of the eighth thoracic vertebra, passing through the central tendon of the diaphragm. It contains the IVC and branches of the right
In rare cases, the right hepatic vein may pass through the caval aperture before joining the IVC.

**Innervation and Vascular Supply**

The vascular supply to the diaphragm is principally composed of the phrenic, pericardiophrenic, and musculophrenic arteries. The phrenic artery is the most cephalad branch of the abdominal aorta, whereas the musculophrenic and pericardiophrenic are branches from the internal thoracic artery. The venous drainage is via the brachiocephalic vein and azygos vein. The diaphragm is primarily innervated by the phrenic nerve, which is formed from cervical nerve roots 3, 4, and 5 (C3, C4, and C5).

**Ligaments of the Liver and the Bare Area**

As reviewed in the discussion of anatomic considerations for the liver, access to the diaphragm for surgical resection of metastatic implants will require complete liver mobilization. This is accomplished by taking advantage of the avascular planes represented by the falciform, coronary, and triangular ligaments. Furthermore, the bare area is retroperitoneal and spared from intraperitoneal tumor spread, allowing it to be used as an anatomic “boundary” for the posterior dissection. The only exception to this rule is in patients with prior liver mobilization. Mobilization of the liver, by careful dissection along the ligamentous attachments, facilitates maximal exposure of the right diaphragm and hepatorenal recess.

**Spleen**

Anatomically, the spleen can be found between the greater curvature of the stomach and the left diaphragm. The hilum of the spleen frequently abuts the tail of the pancreas, whereas the inferior border of the spleen is adjacent to the splenic flexure of the colon (Fig. 12.4). The spleen is held in place by several ligamentous attachments including the gastrosplenic,
splenocolic, splenorenal (also known as lienorenal), and splenophrenic ligaments. The anterior surface of the spleen lies posterior to the stomach and is frequently in contact with the tail of the pancreas.

The blood supply to the spleen comes from the splenic artery, which is a branch of the celiac trunk. The splenic artery runs along the superior border of the pancreas, entering the spleen at the hilum. During its course, the splenic artery gives off several collateral branches that supply the pancreas including the greater pancreatic artery, in addition to the short gastric arteries and left gastroepiploic artery, which perfuse the greater curvature of the stomach and greater omentum. Analogous to the variations seen in hepatic blood flow, there are several anatomic variations in splenic arterial anatomy.

**Pancreas**

Given the anatomic proximity of the pancreas to the splenic hilum, a thorough understanding of pancreatic anatomy is critical for operative exploration of the LUQ. The pancreas is a retroperitoneal organ that is yellow and lies anterior to the abdominal aorta and vena cava at the level of the first and second lumbar vertebral bodies. At the time of operative exploration, the peritoneal reflection overlying the pancreas can be easily appreciated at the base of the lesser sac.

The pancreas is composed of a head, uncinate process, and pancreatic neck, body, and tail. The head of the pancreas is intimately related to the second portion of the duodenum, where the pancreatic head rests in the concavity of the most proximal portion of the small bowel. The head of the pancreas lies anterior to the common bile duct, IVC, aorta, right renal artery, and both renal veins and is covered anteriorly by the transverse colon mesentery. The body of the pancreas is superior to and adjacent to the junction between the duodenum and jejunum and is separated from the body of the stomach anteriorly by the lesser sac. There are several important anatomic structures posterior to the body of the pancreas including the splenic vein, inferior mesenteric vein, and aorta, as well as the left kidney and renal vessels.

The pancreatic tail extends to the left colic flexure and in 40% of patients is within 1 cm of the splenic hilum. Consideration of this relationship is important at the time of splenectomy in order to avoid unrecognized injury to the tail of the pancreas. It is important to note that the pancreatic duct of Wirsung courses through the pancreas, from the tail toward the neck, where it joins the common bile duct, emptying into the duodenum via the ampulla of Vater.

The arterial blood supply to the pancreas arises from branches off of the splenic artery, as well as the left gastroepiploic artery and the pancreaticoduodenal artery. The venous drainage is principally into the splenic vein and superior mesenteric vein.

**Cytoreductive Surgery**

**Cytoreduction of Hepatic Disease**

**Mobilization and Exposure**

For operative outcomes to be optimized, adequate exposure is critical at the time of surgical cytoreduction in patients with advanced-stage ovarian cancer. A vertical midline incision may typically be used, extending from the pubic symphysis to the xiphoid process, particularly when upper abdominal disease is present and operative exploration of the RUQ and LUQ is required. In rare instances, particularly in the morbidly obese patient, a lateral subcostal extension of the incision may be required to improve visualization.

In addition to an adequate incision size, the incorporation of a self-retaining or fixed retractor will facilitate exposure of critical abdominal structures, particularly assisting with upward retraction of the costal margin. Options include the Bookwalter, Omni, Thompson, Upper Hand, or Goligher retractors, which can be used at the discretion of the operating surgeon. In our practice, the Bookwalter (Codman, Raynham, Massachusetts) is used with the addition of a contralateral, second post to allow for additional stabilization with aggressive upward displacement of the costal margin, resulting in excellent exposure of the RUQ and LUQ.

After abdominal entry, a comprehensive exploration is performed to ensure resectability, because aggressive upper abdominal cytoreduction is advocated when resection of all visible disease is the anticipated outcome. The falciiform ligament is identified, skeletonized, cauterized, and transected with the electrosurgical unit (ESU). The dissection of the falciiform ligament is then carried out in the cephalad direction, up to the level of the triangular ligament, with the surgeon remaining cognizant of the hepatic veins as the dome of the liver is approached (Fig. 12.5). With this dissection complete, the liver can be mobilized posteriorly, with improved operative freedom.

**Surface Liver Disease**

Most commonly, patients with metastatic high-grade serous ovarian cancer involving the upper abdomen will have surface liver involvement. This can be addressed by using several surgical techniques including hepatic resection, ablation (with the argon beam coagulator [ABC] or ESU), or a combination of both. Before resection, liver mobilization is performed as described earlier. This is critically important to avoid injury to the vascular structures underlying the reflection of the triangular ligament. If disease implants are identified in Morison pouch, the entire right lobe of the liver must be mobilized by continuing the dissection along the right triangular and coronary ligaments. Full mobilization of the right lobe of the liver will, in addition, require dissection along the left triangular and coronary ligament, allowing the liver to rotate on its central axis.

In some instances the metastatic hepatic implants may be contiguous with the diaphragm’s surface. To address this clinical scenario, the liver is first mobilized and the tumor resected en bloc, inclusive of both a diaphragmatic and hepatic resection. The hepatic disease can then be resected with a more tailored approach by using the ESU or ABC device. If a more substantial resection of liver parenchyma is required because of depth of tumor involvement, typical resection techniques described later in the chapter can be used.

**Parenchymal Liver Disease**

Less commonly, ovarian cancer can metastasize hematogenously, resulting in intraparenchymal liver lesions. In the context of oligometastatic liver parenchymal lesions, excision may be considered to achieve resection of all visible disease. A tailored resection is recommended in order to limit surgically associated morbidity, because wide margins are not required and will undoubtedly be influenced by the regional hepatic anatomy including both hepatic arterial and venous flow.
By far the most frequently encountered clinical scenario is the wedge resection, allowing for the excision of a relatively small liver surface lesion, without anatomic proximity to neighboring hepatic vasculature. Conversely, major hepatic resections, defined as removal of three or more anatomic liver segments, are exceedingly rare and associated with increased morbidity and physiologic liver dysfunction. The intermediate, minor resection, is defined as resection of one or two liver segments and facilitates the preservation of liver parenchyma, decreasing morbidity.

**Nonanatomic Wedge Resection**

The nonanatomic wedge resection is commonly used for the removal of surface liver lesions, either isolated or affecting both the right and the left lobes of the liver. There is no defined size cutoff, although adequate exposure and liver mobilization are critical in the event of unanticipated blood loss and to avoid inadvertent injury to underlying structures.

Careful review of any preoperative imaging studies should be conducted before resection of hepatic lesions, and, when available, intraoperative review of radiographic images is recommended to ensure that all areas of suspicion are explored. After liver mobilization, careful visual inspection and palpation are performed, and areas of disease identified. Once again, resection should be performed with the goal of removing all grossly visible disease and should be reconsidered in patients in whom this is not a realistic surgical outcome. Use of intraoperative ultrasound can be considered if there is concern for additional intraparenchymal liver lesions.

After hepatic mobilization (as discussed earlier), the target lesion should be in clear view within the surgical field. With electrosurgical energy, the liver capsule is circumferentially incised around the metastatic implant, without concern for a widely negative margin (Fig. 12.6). If desired, a series of vertical mattress sutures may be placed by using a large-caliber (No. 1 or 0) chromic suture parallel to the electrocautery line, compressing the hepatic parenchyma and theoretically decreasing the risk of blood loss. The intervening tissue can then be removed using the ESU. Alternatively, a vessel-sealing device, such as the LigaSure (Medtronic, Minneapolis, Minnesota), can be used to compress, coagulate, and divide the hepatic tissue surrounding the target lesion. If required, resection bed bleeding can be managed with the ABC, ESU, or pressure with use of hemostatic thrombin–containing agents. In the event of a bile duct leak, the culprit should be identified and ligated or clipped. If the leak cannot be controlled, drainage is required and resolution with conservative management is common.

**Total Inflow Occlusion**

Although uncommonly employed, surgeons performing hepatic resections and operating in the RUQ should be comfortable with the Pringle maneuver—compression of the hepatic inflow vasculature within the portal triad (Fig. 12.7). This is most easily accomplished by passing the index finger through the foramen of Winslow and the thumb above the hepatoduodenal...
ligament. A window can then be created in an avascular plane along the gastrohepatic ligament (lesser omentum), and if required a vessel loop or vascular clamp can be placed across the pedicle. In patients with normal hepatic function, occlusion can be safely tolerated for up to 60 minutes without irreversible liver damage. This is not the case for patients with preexisting liver disease, in whom intermittent occlusion lasting approximately 10 minutes should be employed, allowing for occasional reperfusion.

**Major and Minor Hepatic Resections**

As previously mentioned, major and minor hepatic resections are not commonly performed at the time of ovarian cancer cytoreduction. Nonetheless, the surgical principles are based on a thorough understanding of the inflow and outflow structures supplying the liver parenchyma—namely, the portal vein, hepatic artery, and hepatic vein. This anatomic relationship is based on Couinaud’s segments, with identification and control of the inflow pedicles primarily (hepatic artery and portal vein), followed by the outflow pedicles (hepatic vein), and finally transection of the liver parenchyma. Careful identification of the underlying vascular structures can be accomplished with meticulous dissection and surgical technique in combination with a systematic understanding of segmental liver anatomy. Furthermore, intraoperative liver ultrasound can be used.

Principally, right and left hepatic resections are performed in a similar manner. The liver is fully mobilized by incising the falciform ligament, followed by the triangular and coronary ligaments until the bare area is reached. With adequate exposure, the priority becomes control of the inflow pedicles. The right and left hepatic artery and portal venous branches are commonly identified at the hilum of the liver and can be secured extrahepatically. Before transection, the appropriate pedicles can be compressed with a vessel loop or vascular clamp to allow for a blanching of the hepatic tissue, creating a line of demarcation and ensuring adequate blood supply to the preserved portion of the liver.

With respect to hepatic outflow, the hepatic veins are similarly identified, based on hepatic segmental anatomy. The required hepatic vein (right, middle, or left) is isolated and ligated, with use of intraoperative ultrasound as required. Ligation of the middle hepatic vein is optional and may accompany either a right or a left partial hepatectomy.

Following and in conjunction with control of the major vascular pedicles as outlined earlier, division of the liver parenchyma can be accomplished by using a variety of sources including traditional electrocautery, blunt fracture, the LigaSure vascular sealing device, the Harmonic scalpel (Ethicon Endo-Surgery, Somerville, New Jersey), the ABC, or a stapling device. Studies examining the various modalities have been conducted with inconsistent conclusions. Commonly, the liver parenchyma is fractured using the Cavitron ultrasonic surgical aspirator (CUSA) or forceps (clamp-crush method). After the parenchyma has been crushed, the exposed vessels and biliary structures are ligated or clipped as they are encountered. Ultimately, the modality that is employed is based on surgeon preference and comfort.

The use of major hepatectomy in cytoreduction, defined as resection of three or more Couinaud liver segments, is uncommon in patients with metastatic intraparenchymal liver metastases. Nonetheless, the surgical principles employed are parallel to those outlined earlier, with sequential control of inflow and outflow vascular structures and division of the liver parenchyma after natural demarcation based on hypoperfusion. A cholecystectomy is performed in conjunction with a right hepatectomy.

**Liver Ablative Techniques**

**Radiofrequency Ablation**

Radiofrequency ablation (RFA) results in focal coagulative necrosis and relies on the delivery of alternative electrical currents with frequency of 460 to 500 kHz. The alternating current results in agitation of dipolar molecules and subsequent thermal injury to the hepatic tissues. This is completed by using a multipronged expandable electrode that is directly inserted into the liver parenchyma at the target site and activated for 4 to 6 minutes, under ultrasound guidance. RFA can be used during open surgical approaches or transcutaneously under computed tomographic guidance. Complications associated with RFA include thermal injury to adjacent structures, portal vein thrombosis, hemorrhage, and bile duct fistula. More commonly, patients will experience RUQ pain and a transient elevation of liver enzymes.

**Microwave Ablation**

Microwave ablation (MWA) has emerged as a promising therapeutic modality in patients with metastatic hepatic lesions. In contrast to RFA, MWA works by active heating of water molecules via an electromagnetic field, resulting in more rapid ablation in a homogeneous manner. Leung and colleagues detailed the safety and efficacy of MWA with or without liver resection in the treatment of liver tumors. Common adverse events in patients undergoing MWA include RUQ pain, abscess formation, bile leak, bleeding, and thromboembolism.
Cryoablation

During cryoablation, liquid nitrogen or argon gas is delivered to the metastatic liver lesion under ultrasound guidance by using a specialized cryoprobe, resulting in ice crystal formation and tumor cell destruction. Secondary to its unfavorable side effect profile, cryoablation is used significantly less frequently than RFA or MWA. A common cryoablation protocol consists of two 10-minute freeze cycles with an intervening 5-minute thaw period. In 2013, researchers performed a Cochrane meta-analysis and concluded that there was insufficient evidence to support the use of cryoablation in the treatment of metastatic hepatic lesions.23

Porta Hepatis Disease

Uncommonly, metastatic ovarian cancer implants can be identified in the porta hepatis. Given the critical structures housed in the hepatoduodenal ligament, an understanding of the anatomy is pivotal to successful resection. Furthermore, attempts at cytoreduction of disease in this location should be done when the anticipated surgical outcome is resection to no gross visible residual disease. Once the portal vein, hepatic artery, and common bile duct have been identified and skeletonized, the metastatic disease can be dissected off of the underlying structures, because infiltrative growth patterns are uncommon. Given the serious morbidity associated with unintended injury to the porta structures, hepatobiliary surgeons with experience in this anatomic region should be consulted for intraoperative assistance. Similar techniques are employed when porta hepatic adenopathy is identified on preoperative imaging and the plan for resection is made. All vascular and biliary structures should be clearly identified and protected.

Cytoreduction of Diaphragmatic Disease

Exposure

Diaphragmatic disease is commonly found in patients with metastatic ovarian cancer involving the RUQ. Surgical resection requires adequate exposure, which is dependent on selection of an appropriate abdominal incision. We most commonly use a vertical midline incision that extends from the pubic bone to immediately below the xiphoid process, particularly when multiquadrant surgical resection is required (both pelvic and upper abdominal disease). In the less common scenario of targeted resection of recurrent diaphragmatic disease, a subcostal incision can be performed, although this significantly limits exploration of the remainder of the abdominal cavity and is therefore not advocated. Robotic-assisted surgery and laparoscopy have been described for the resection of diaphragmatic disease, although both limit retrohepatic exploration.24 Furthermore, if there is bulky diaphragmatic disease, robotic and/or laparoscopic resection may be inadequate.

The patient can be positioned in the low dorsal lithotomy position or supine on the operating room table. The low lithotomy position allows the surgeon to stand in the midline, looking up into the hepatic recess, directly at the diaphragm’s surface, potentially assisting with exposure and resection. In addition, the reverse Trendelenburg position can be used as a mechanical advantage, dropping the liver out of the RUQ after hepatic mobilization, further exposing the abdominal surface of the diaphragm. The primary surgeon thus has the option of standing between the patient’s legs or on the side of the patient, contralateral to the diaphragmatic disease being resected.

Once again, a self-retaining retractor is used, allowing for maximal upward displacement of the costal margin. When the Bookwalter is used, it is our practice to use two posts fixing the ring to the operating room table, allowing for increased stabilization despite aggressive upward traction. The Omni-Tract Surgical, St. Paul, Minnesota) is also commonly used in hepatobiliary surgical procedures.

Liver Mobilization

Given the frequency of diaphragmatic involvement in patients with advanced-stage ovarian cancer, thorough palpation and visible inspection of the RUQ are required to avoid an unintended surgical outcome of gross residual disease. This can be performed only with an adequate incision in conjunction with hepatic mobilization. Reliance on preoperative computed tomography or positron emission tomography imaging alone to identify small-volume diaphragmatic disease is inadequate.

As previously discussed, liver mobilization begins with identification and transection of the round ligament by using a bipolar energy device, followed by identification and transection of the falciform ligament. The leaves of the falciform are then dissected back toward the diaphragm by using electrosurgical energy, ultimately leading the surgeon to the bilateral triangular and coronary ligaments. Any disease deposits involving the round ligament or falciform ligament should be resected at this time. With dissection of the coronary ligaments, care must be taken to avoid injury to the underlying right and left hepatic veins.

For adequate exposure of the right diaphragm to be achieved, complete hepatic mobilization is required. Specifically, with dissection of the right hepatic ligaments alone, rotation of the liver medially and inferiorly may result in significant vascular congestion. To allow the liver to rotate on its vascular axis, avoiding the hinge effect, the left triangular and coronary ligaments should also be released. Division of the hepatogastric ligament will also assist in full mobilization of the left hepatic lobe.

The right-sided dissection is then continued by cauterying and transecting the right coronary ligament, working from medial to lateral. The right liver parenchyma can then be mobilized medially, bringing into the operative field the right paracolic gutter and Morison pouch. Dissection should be performed close to the liver surface. Progressive dissection and medial mobilization will allow for exposure of the bare area of the liver and visualization of the right kidney and adrenal gland and a panoramic view of the right hemidiaphragm.

In some instances, the operating surgeon may prefer to begin the dissection laterally, working from the right triangular ligament in the direction of the falciform ligament medially. If a large adherent tumor plaque results in agglutination of the liver surface and diaphragm peritoneum, the surgeon has two options. In one approach the metastatic implant can first be dissected off of the liver surface by using electrosurgical energy or the ABC. This will allow for access to the anterior layer of the coronary ligament and completion of the diaphragm peritoneectomy in a more traditional fashion. Conversely, the surgeon may elect to dissect the tumor off of the adjacent diaphragmatic musculature by incising the diaphragm peritoneal reflection ventral
Chapter 12 Radical Upper Abdominal Surgery: Liver, Diaphragm, and Spleen

...If the appropriate plane is difficult to define, and removed as the subpleural plane. Liver mobilization is performed as described earlier, and the peritonectomy is started in a traditional fashion. When the affected area has been identified, confirming obliteration of the subpleural plane, the ESU can be used to incise across the full thickness of the diaphragm muscle, exposing the pleural space and the pleural aspect of the diaphragm muscle. A gross tumor margin of approximately 0.5 cm is the goal (Fig. 12.9).

During resection, traction placed on the specimen will both allow for correct orientation and facilitate ESU effectiveness. The incision should be carried parallel to the branching phrenic nerve to avoid unnecessary injury and limit diaphragmatic dysfunction after the operation. During resection, branches of the phrenic artery and vein can be encountered and may need to be controlled with a suture ligature or bipolar energy device. After removal of the specimen, the abdominal and peritoneal surfaces should be identified for the pathologist. The pleural cavity can also be visibly and manually explored to evaluate for disease. In addition, evaluation for the presence of an enlarged cardiophrenic lymph node can be performed at this time.

In nearly all instances, primary closure of the diaphragm can be completed with either interrupted figure-of-eight sutures or a running locked stitch by using a 1-0 or 2-0 nonabsorbable monofilament suture. The diaphragm defect should be along its axis to minimize tension. The closure should begin at the apices, working toward the midline. Before the final suture is secured, a fenestrated 14F red Robinson catheter is placed into the pleural space, and in conjunction with positive-pressure ventilation by the anesthesiologist, the catheter is connected to low continuous suction evacuating the pneumothorax, and removed as the final stitch is secured. The RUQ is then filled with fluid as the patient is placed in the Trendelenburg position, and a bubble test is performed by giving large-volume positive-pressure breaths, examining for the presence of a residual diaphragm defect. Absence of bubbles confirms an airtight closure. A postoperative chest radiograph is obtained to evaluate for a residual pneumothorax.

In some instances, the operating surgeon may elect to place a chest tube to protect against a postoperative pneumothorax. This is of particular value when aggressive RUQ cytoreduction inclusive of diaphragm peritonectomy or full-thickness resection is combined with hyperthermic intraperitoneal chemotherapy. Placement of a 28F chest tube is done in a retrograde fashion by passing the chest tube through the diaphragm defect, exiting within the fifth or sixth intercostal space in the midcostal plane. The tip of the chest tube is then directed into the superior aspect of the lung manually, avoiding injury to the underlying...
Spleen

Exposure

As previously described, exposure of the upper abdomen is dependent on an appropriate incision and use of a self-retaining retractor. For access to the spleen, the left costal margin is retracted superiorly and laterally. The patient can be placed in a reverse Trendelenburg position as well. Once again, the surgeon can stand on the right side of the patient or between the patient’s legs if the patient is in a modified lithotomy position, to gain a panoramic view of the LUQ. Before resection, a thorough examination should be performed to define the extent of disease in the LUQ and to determine what organs are affected and will need to be resected. This will help guide the surgical plan, dictating whether a piecemeal or en bloc resection will be required.

Splenectomy

In up to 30% of patients, a splenectomy is required as part of ovarian cancer cytoreduction.29

It is the second most commonly performed upper abdominal procedure after diaphragm peritonectomy. Furthermore, patients whose cytoreduction involves splenectomy more commonly require diaphragm peritonectomy and radical pelvic surgery. In the presence of disease, the splenic hilum is most commonly involved, followed by the surface of the spleen, and finally the parenchyma.30 It is important to note, however, that not all cases of suspected disease involvement are confirmed on histologic analysis of the resected specimens. Rarely, splenectomy is required because of intraoperative trauma encountered when there is excessive traction on the omental pedicle resulting in splenic vascular injury.

In addition to resection at primary operation, isolated splenic metastases may be seen in patients with recurrent disease. In this setting a subcostal incision or laparoscopic approach may be used.31 Principally, splenectomy can be performed by means of an anterior or posterior approach, dictated by the distribution of disease. Irrespective of the approach used, an understanding of the anatomy is critical (Fig. 12.10).

Posterior Approach

Commonly, LUQ splenic involvement with metastatic disease is associated with a bulky omental and gastrocolic tumor burden. This disease distribution precludes the anterior approach, and the operating surgeon should be comfortable approaching splenectomy posteriorly.

Initially the stomach is decompressed by means of an oral gastric or nasogastric tube placed on low continuous suction. The decompressed stomach is then placed on medialized traction by using a Babcock clamp. The gastrocolic ligament is left undisturbed. Attachments between the spleen and the anterior abdominal wall and left diaphragm are taken down with
electrosurgical energy and blunt dissection. The splenocolic ligament is identified, and, if not already taken down as part of the omentectomy, it is cauterized and transected with the bipolar energy device. This dissection then allows for mobilization of the spleen superiorly and medially, bringing it into the operative field. The patient should be in the reverse Trendelenburg position at this stage to allow for the colon and small bowel to fall away from the LUQ.

At this point the splenorenal (or lienorenal) ligament is incised, freeing the spleen from the left kidney. Further rotation of the specimen then allows for posterior palpation of the splenic vessels. It is important to note that in up to 75% of cases, the tail of the pancreas lies within 1 cm of the splenic hilum and should be mobilized sufficiently to avoid injury as the splenic vessels are secured. The splenic artery can then be cauterized and transected with a bipolar ESU, or alternatively double suture ligated and transected with a permanent silk suture. The splenic artery should be ligated primarily, allowing for autotransfusion and splenic decompression before the splenic vein is ligated and transected. In both open and laparoscopic approaches, the endo-GIA with a vascular load can also be used to secure and transect the splenic vascular pedicles. The artery and vein should be divided individually to avoid arteriovenous fistula formation.

After the primary vessels have been secured, the specimen is rotated further in the medial direction and the remainder of the gastroepiploic ligament, inclusive of the short gastric vessels, is cauterized and transected with a bipolar vascular sealing device. The RUQ can then be drained by using a 15F Jackson-Pratt drain.

**Anterior Approach**

If the anterior surface of the spleen is free of disease, the anterior approach affords the most direct route to secure the splenic vascular supply. As part of the omentectomy, the gastrocolic ligament is incised and the left gastroepiploic vessels are cauterized and transected. This facilitates entry into the lesser sac, and the body and tail of the pancreas can be identified along the floor of the lesser sac. Medial traction is once again used on the decompressed stomach, and the inferior aspect of the gastroepiploic ligament is taken down by using the vascular sealing device or laparoscopic stapler. The splenic artery can then be identified coursing immediately superior to the pancreas. The peritoneum overlying the pancreas is carefully incised, and the splenic artery is skeletonized with a right angle clamp, secured via ligatures, and transected. Once again, a vascular stapling device can be used if desired. Care to avoid injury to the underlying pancreas is important. After the splenic artery has been secured, autotransfusion occurs, and any remaining short gastric vessels can be secured via the vessel sealing device. The splenic vein is then isolated, suture ligated, and transected. The spleen can then be rotated medially and superiorly, and the lateral attachments taken down in a manner analogous to that employed in the posterior approach. Once again, care should be taken to avoid injury to the pancreatic tail during dissection, and a drain is placed in the LUQ.

**Laparoscopic Splenectomy**

In cases of isolated splenic recurrence, a minimally invasive approach can be used to decrease operative morbidity and allow for more rapid recovery and initiation of chemotherapy. The patient is placed in the right lateral decubitus position with the table flexed to open the LUQ. Four laparoscopic sites are traditionally used, placed in an orientation facing the LUQ. As detailed earlier, the splenic flexure is mobilized primarily, and the splenocolic ligament is then incised with a laparoscopic vascular sealing device. The lateral splenic attachments (splenophrenic and splenorenal ligaments) are then incised, allowing for improved medial mobilization of the spleen. The dissection is directed medially, with coagulation and transection of the short gastric vessels as they course through the gastroepiploic ligament. The splenic artery and vein are identified and secured with a laparoscopic vascular sealing device.

**Splenic Injury**

The most common indication for iatrogenic splenectomy is splenic laceration due to traction at the time of omentectomy. Excessive traction can lead to vascular injury or splenic capsule trauma and bleeding. Attempts at conservative management can be made with topical hemostatic agents such as Surgicel or Fibrillar (Ethicon Inc. US, Somerville, New Jersey), or with the application of pressure using laparotomy sponges in conjunction with Floseal (Baxter, Deerfield, Illinois). Energy devices such as the ABC can also be used to control surface bleeding. The use of an omental pedicle to tamponade the surface bleeding has also been described. Ultimately, in the event of a significant surface injury or hilar injury, conservative measures should be abandoned and a splenectomy performed.

**Distal Pancreatectomy**

The tail of the pancreas is intimately associated with the splenic hilum. In some cases the presence of metastatic disease involving the tail of the pancreas may necessitate a distal pancreatectomy. In prior series, the frequency of distal pancreatectomy was reported to be as high as 11% at the time of surgical cytoreduction.

The distal pancreatectomy is performed as a continuation of the splenic dissection as outlined earlier. With the anterior or posterior approach, the spleen is mobilized superiorly and medially, with excellent exposure of the LUQ structures and dissection of the spleen off of its lateral attachments. The posterior peritoneal reflection of the pancreas is identified and blunt dissection used, allowing for elevation of the tail of the pancreas with the primary specimen.

It is important to understand the anatomic location of the splenic vein posterior to the body of the pancreas and to also anticipate drainage of the inferior mesenteric vein into the splenic vein. The inferior mesenteric vein should be preserved unless tumor location mandates it be sacrificed. Once elevated, the resection line and extent of distal pancreatectomy are governed by tumor distribution and desire for complete gross resection. The pancreatic tissue can be transected by using an ESU, or alternatively a vascular stapler with a dissolvable tissue bolster. If a stapling device is used, there is no defined benefit to reinforcing the staple line with separate sutures. When the bipolar device is used, there is no defined benefit to reinforcing the staple line with separate sutures. When the bipolar device is used, the resection margin can be reinforced with a 2-0 silk or alternate delayed absorbable suture. Once again, the LUQ can be drained with a closed suction 15F Jackson-Pratt drain, although this has not been shown to reduce postoperative complications.

**Radical en Bloc Left Upper Quadrant Resection**

If there is an extensive conglomerate of tumor in the LUQ distorting normal anatomy and tissue planes, a radical en bloc
resection may be required. This procedure should be reserved for cases in which the surgical outcome is anticipated to be no gross residual disease. Such contiguous lesions may involve the transverse colon, omentum, greater curvature of the stomach, left diaphragm, distal pancreas, and spleen. Before committing to such an extensive resection, one should conduct a comprehensive assessment to ensure feasibility and confirm that reestablishing intestinal continuity after cytoreduction is possible.

Although radical in nature, this procedure essentially combines the principles previously reviewed in this chapter. After adequate exposure of the LUQ has been achieved, this procedure is most commonly started by mobilizing the left lobe of the liver. The falciform, left coronary, and left triangular ligaments are incised sequentially, allowing for medial mobilization of the left lobe of the liver. Attention is directed to the omentectomy, which is commonly completed in conjunction with a transverse colectomy. The portion of involved transverse colon is incorporated in the specimen, with the adjoining omentum dissected free of the hepatic and splenic flexures at the time of bowel mobilization to facilitate reanastomosis. With omentectomy initiated, the lesser sac is entered and palpated to ensure resectability and to better define the extent of disease. Because no established order of events has been defined for this resection, the procedure is best performed in an opportunistic fashion, working to avoid injury to underlying structures and vascular pedicles.

If the disease extends onto the greater curvature of the stomach, a partial gastrectomy may be required. The decompressed stomach is retracted medially, and the posterior gastric wall is brought into view. Once again the lesser sac will have been opened as part of the dissection, and the portion of the gastrocolic ligament replaced with tumor well defined. Lateral and downward traction is then placed on the tumor mass, and the disease-free portion of the greater curvature of the stomach is identified. With a GIA stapling device with a 4.8-mm load, the stomach is stapled along its linear axis, and the involved segment is excised. The staple line may be oversewn with silk suture at the discretion of the physician. With resection of the omentum, transverse colon, and a portion of the stomach, attention can be directed to the affected spleen. In such instances the posterior approach is used, given the degree of anterior tumor bulk involving the gastrosplenic ligament.

Occasionally, a left diaphragm peritonectomy will be required to facilitate complete resection and allow for splenic mobilization. Consistent with the principles of diaphragm peritonectomy, the subpleural space is developed and the diseased peritoneum removed. A full-thickness resection may be required. The lateral approach can also be used, extending the peritoneal dissection from the splenorenal and phrenocolic ligaments toward the diseased portion of the omentum. With mobilization of the left diaphragmatic disease, the en bloc specimen can be rotated further in the medial and superior directions, bringing the specimen into the operative field. Last, the splenic vessels and distal pancreas are isolated and transected as previously detailed. The LUQ is drained at the completion of the resection in conjunction with nasogastric decompression.

**Conclusion**

The intent of primary cytoreduction in patients with advanced-stage ovarian cancer is the removal of all visible disease. As outlined earlier, a significant portion of patients will have tumor involvement of the RUQ and LUQ, necessitating exploration and surgical resection to achieve the desired surgical outcome. Gynecologic oncologists are comfortable with the management of pelvic disease; however, the upper abdominal area can at times pose a difficult surgical challenge.

On review of the anatomic considerations and the techniques employed for upper abdominal cytoreduction, it is evident that upper abdominal surgery is both safe and feasible, and it should be included in the surgical armamentarium of practicing gynecologic oncologists. Certainly, appropriate patient selection, surgeon comfort, and availability of specialized postoperative care are required to maximize the odds of a successful intervention and recovery while reducing morbidity.

It is important to note that if the RUQ and LUQ are ignored at the time of primary cytoreduction, which frequently occurs when the area is not adequately explored, complete surgical cytoreduction may not be achieved, compromising oncologic outcomes.

**References**


Pelvis

In early stages, removal of the adnexa involved by tumor, a total abdominal hysterectomy with bilateral salpingo-oophorectomy, pelvic and paraaortic lymphadenectomy, and omentectomy are required as part of the surgical staging. Conservative procedures including unilateral salpingo-oophorectomy may be an alternative in young patients with early-stage disease and desire to preserve their fertility. In advanced stages, it is very common to find the internal genitalia (uterus and adnexa), the posterior cul-de-sac, the surface of the rectosigmoid colon, and most of the pelvic peritoneum, including the prevesical peritoneum and the lateral pelvic peritoneum, coated with tumor nodules of different dimensions (small implants, bulky nodules, or tumor plaques). Although it is not an infrequent occurrence for tumor to deeply infiltrate the rectosigmoid colon, it is very unlikely that the urinary tract itself is infiltrated by tumor.

The type of operation that should be performed is mainly dependent on the surgical findings, the tumor locations, and the surgeon’s expertise. The tumor tends to remain superficial, without a deep invasion of the adjacent organs. The retroperitoneum is almost always preserved from tumor infiltration. Removal of the tumor usually requires a retroperitoneal approach, which allows the identification of the vasculature and the isolation of the ureters laterally. At the same time, the peritoneum in the pelvis can be safely removed with the internal genitalia. If the tumor does not involve the wall of the rectosigmoid colon, the peritoneum of the pelvis and cul-de-sac can be stripped away. The lateral and anterior peritoneum is usually easy to dissect once the ureters have been lateralized, and the bladder is dissected off the uterus. If the tumor involves the wall of the rectosigmoid colon, a radical oophorectomy with en bloc resection of the rectosigmoid is preferred. Restoration of the bowel continuity is then performed and constitutes one of the most delicate parts of the surgical procedure. This chapter defines different approaches that can be used to remove all the tumor present in the pelvic area, according to the tumor distribution. This operation was first defined by Hudson as “radical oophorectomy” and subsequently has been redefined by several authors.

Surgical indications for this type of operation can be found in the context of either a cytoreductive effort (cytoreduction for primary or recurrent tumor) that brings the patient to no (or nearly no) macroscopic residual disease or a palliative goal of removing a tumor that is causing symptoms from a bowel obstruction. The patient must be evaluated preoperatively and judged able to withstand a complex procedure, and she must give consent for temporary bowel diversion if needed (intraoperatively or postoperatively because of complications).

Retroperitoneum

Accurate retroperitoneal staging is critical in patients with early ovarian cancer. The main value of the procedure lies in its ability to allow potential identification of nodal metastases; an appropriate adjuvant treatment method can be recommended according to the pathologic findings. In fact, a randomized trial comparing systematic pelvic and paraaortic lymphadenectomy versus nodal sampling showed that the ability to detect nodal metastases was higher in the lymphadenectomy arm (22% vs. 9%). Less adjuvant treatment was given in the lymphadenectomy arm, and a trend toward better progression-free survival (PFS) and overall survival (OS) was noted.

A 2011 review examining the incidence of nodal metastases in 14 different studies showed that the mean incidence of pelvic or paraaortic nodal involvement in apparent stages I and II epithelial ovarian cancer was 14.2% (range, 6.1%–29.6%). In grade 1 tumors and with mucinous histology, the rate of nodal involvement was very low (almost negligible); for this specific reason, several authors do not recommend performance of systematic pelvic and paraaortic nodal dissection under these circumstances. Identifying those patients with disease grossly confined to the ovaries and pelvis but with retroperitoneal dissemination (stage IIIA1 according to the new International Federation of Gynecology and Obstetrics [FIGO] classification) may allow the most accurate adjuvant treatment planning. On the other hand, if patients truly have stage I disease, this may result in less adjuvant treatment if not indicated. If grossly involved nodes are found during the preoperative workup or during the operation, these should be removed as part of a debulking procedure.

In patients with advanced ovarian cancer, pelvic and/or paraaortic lymph nodes are a common site of metastasis, exceeding 50% of patients in most series.
A randomized trial comparing a systematic pelvic and paraaortic nodal dissection versus resection only of “bulky” nodes in patients with advanced ovarian cancer debulked to less than 1 cm has been completed. Although 5-year PFS was significantly higher in the lymphadenectomy arm (31.2% vs. 21.6%), OS did not statistically differ between the two arms (48.5% vs. 47%). In an analysis of data from three randomized trials in advanced ovarian cancer patients from the AGO (Arbeitsgemeinschaft Gynaekologische Onkologie) group, du Bois and colleagues showed a significant survival benefit in patients without residual disease but not in patients with a small amount of residual disease. They also found a significant impact of lymphadenectomy on survival in patients with low-volume disease and clinically involved bulky nodes. Although debulking of grossly involved nodes appears to be rational when a complete cytoreduction to no gross residual disease is performed in the abdominal cavity, the value of a complete lymphadenectomy when lymph nodes are not enlarged is not established. For this reason, an international prospective randomized clinical trial comparing systematic lymphadenectomy versus no lymphadenectomy in patients with advanced ovarian cancer debulked to no gross residual disease will probably be able to definitively address this issue. The trial has recently completed accrual.

The general approach for removing pelvic and paraaortic nodes is to access the retroperitoneum and define the anatomic structures and the surgical boundaries of the dissection. Removal of the pelvic nodes is commonly within the surgical armamentarium of most pelvic surgeons. Removal of the nodes from the paraaortic region usually requires greater expertise. Surgical steps include mobilization of the ascending colon, identification of the renal veins, and removal of the node-bearing tissue from the perirectal and pararectal area, the intercavoaortic area, and the left paraaortic basins. Removal of bulky nodes can indeed be a challenge in both the pelvic and the paraaortic areas, and particular attention should be paid to the important structures (arteries and veins, nerves, ureters) to avoid injuries that can be difficult to manage. Anomalies of the vascular system (particularly in the aortocaval region) and in the urinary system are not uncommon, and while performing a retroperitoneal dissection, the surgeon should be aware of the different anomalies. In this respect, a careful evaluation of the preoperative imaging (computed tomography [CT] scan) is helpful in making an adequate surgical plan. Bulky nodes cephalic to the renal veins can also be a challenge in the debulking procedure. A common location of grossly involved nodes is at the level of the celiac axis. In this area, an injury of the superior mesenteric artery may in fact result in compromise of the blood supply to the small bowel.

This chapter describes a step-by-step procedure to remove the pelvic and paraaortic nodes.

Retroperitoneal Node Dissection

Three approaches to the surgical staging of ovarian carcinoma have been described: transperitoneal laparotomy, extraperitoneal laparotomy, and endoscopic approach. The endoscopic technique can actually be performed either transperitoneally or extraperitoneally as well as by means of laparoscopy or use of the da Vinci robotic surgical system. Endoscopic staging has the advantages of a more rapid recovery of the patient and a lower postoperative complication rate, thus avoiding significant delay in initiating adjuvant chemotherapy if necessary. In patients with advanced disease, however, laparotomy is recommended.

Pelvic Lymphadenectomy: Surgical Technique

The beginning of the procedure includes the definition of the margins of the operative field with the development of the avascular spaces of the pelvis and then the removal of the nodal tissue within those margins. Box 13.1 gives a step-by-step description of pelvic lymph node dissection.

Step 1: Dissection of the Avascular Spaces of the Pelvis

The pelvic peritoneum is opened over the psoas muscle 1 cm lateral and parallel to the ovarian vessels. The posterior fossa or pararectal space is dissected laterally to the ureter and medi-ally to the internal iliac artery (Fig. 13.1). The uterine artery is the anterior limit, the lateral border of the rectum is the medial limit, and the internal iliac vessels are the lateral limits of the pararectal space (Fig. 13.2). The round ligament is then divided, and the anterior peritoneum is incised laterally and parallel to the obliterated umbilical artery (Fig. 13.3). The dissection progresses in depth, and the anterior fossa or paravesical space is developed. The lateral limit is the internal obturator muscle, the medial limit is the bladder, and the posterior limit is the uterine artery (Fig. 13.4).

The distal external iliac vessels and lymph nodes are exposed by placing upward traction on the lateral part of the transected round ligament with a retractor to separate the fatty retrocrural nodal tissue from the peritoneum and undersurface of the inguinal ligament.

The external iliac artery and vein are separated from the psoas muscle. This step allows identification of the obturator fossa with the obturator nerve in the depth of this space.

**BOX 13.1 Step-by-Step Paraaortic Lymph Node Dissection**

1. Peritoneal incision and exposure of the area of dissection
2. Dissection of the paracaval nodes
3. Dissection of the inferior paraaortic nodes
4. Dissection of the superior paraaortic nodes
5. Dissection of the intercavoaortic nodes

**FIG. 13.1** Initial dissection of the pararectal space.
The dissection starts proximally behind the bifurcation of the common iliac artery (Fig. 13.5) and distally into the paravesical space, taking care not to injure the accessory obturator vein. The dissection over the psoas muscle is continued distally up to the deep circumflex iliac vessels.

The dissection progresses in depth, and the external iliac vessels are retracted medially and the psoas muscle is retracted laterally, allowing the identification of the obturator nerve, which emerges under the psoas muscle behind the bifurcation of the common iliac artery. The fat tissue containing the obturator...
nodes is stripped from the nerve for 3 to 4 cm into the obturator fossa. Special care should be taken because one or two small branches from the obturator artery to the pelvic wall are often encountered in the proximal obturator fossa; these are clipped. All vessels in the obturator fossa lie below the obturator nerve except the accessory obturator vein.

**Step 2: Separation of the Nodal Tissue From the Iliac Vessels**

The nodal fat tissue, previously mobilized from the psoas muscle lateral to the external iliac artery, is pulled medially over the artery, and the plane of dissection between the adventitia of the artery and the areolar tissue is developed. The tissue is dissected from the external iliac artery distally to the inguinal ligament and proximally to the bifurcation of the common iliac artery. Some of the filaments of the genitofemoral nerve run through this area, but typically they can be isolated to avoid paresthesias of the upper anterior thigh. A vein retractor can be used to elevate the artery and vein to complete the dissection of the vessels.

To avoid injury to the external iliac vein, the dissection of the proximal one-third of the artery can be deferred until the vein is clearly exposed.

In dissecting the undersurface of the vein and the cranial half of the obturator fossa, special care must be taken because the confluence of the hypogastric vein and the external iliac vein could be easily injured. Therefore it is prudent to carefully dissect until the juncture of these major veins and the superior surface of the hypogastric vein have been identified.

Before the superior and posterior surfaces of the proximal and distal external iliac vein are completely cleared, the common and external iliac vessels are retracted medially to expose their lateral side and the obturator nerve completely.

With elevation of the external iliac vein, the obturator nerve is exposed; the nodal fat tissue is stripped from the nerve to the distal end of the obturator fossa by pulling the specimen upward. The obturator artery and vein are usually inferior to the nerve. When the nodal tissue has been mobilized, the only distal connection of the fat pad is a pedicle of tissue that passes over the superior pubic ramus connecting the obturator nodes to the femoral canal, which is clipped or ligated. The accessory obturator vein, if present, may need to be ligated.

To clear the obturator fossa below the obturator nerve, the obturator artery and vein are clipped near the obturator canal; the fat tissue posterior to the obturator vessels is removed by gentle traction. Small branches of the obturator vessels to the pelvic wall are clipped as they are encountered. The specimen is dissected from lateral to medial and distal to proximal. The fatty tissue around the posterior parietal branches of the hypogastric artery (inferior gluteal, internal pudendal) are then carefully removed.

In the proximal and lateral part of the obturator fossa, the sciatic nerve roots are exposed laterally and the hypogastric veins medially. The hypogastric lymph nodes are medial and posterior to the hypogastric and common iliac artery, covering the medial surface of the common iliac and hypogastric vein, and are carefully removed.

**Step 3: Removal of the Common Iliac Nodes**

The dissection of the right and left sides is different. On the right side, the common iliac vein is lateral to the artery, whereas on the left side the vein is under and medial to the artery.

The lateral and medial margins of the dissection are identified; the areolar tissue is incised for the length of the vessels and dissected from them with use of vein retractors as needed. The common iliac veins may have significant tributaries including the iliolumbar vein and, on the left side, the middle sacral vein. The lateral common iliac nodes are typically removed as a component of the complete pelvic node dissection.

### Aortic Node Dissection

**Anatomic Considerations**

Variations in the branches of the aorta and tributaries of the vena cava can be common. The most commonly encountered variants of the arterial system involve the course of the renal arteries, including the presence of an accessory right renal artery to the lower pole of the kidney. The left renal artery may be just cephalad or caudal to the renal vein, or immediately dorsal to it, so it may be encountered in the dissection of the left proximal aortic nodes. The right renal artery sometimes takes a caudal course between the vena cava and the aorta before passing under the vena cava to the right kidney. It may be encountered during the dissection of the proximal aortocaval or right paracaval nodes. The right accessory renal artery is a small vessel, perhaps 2 to 3 mm in diameter, crossing over the distal vena cava; it may be encountered in the dissection of the distal precaval, aortocaval, and right paracaval nodes. Disruption of this artery devascularizes the inferior pole of the kidney.

Venous anomalies are more common on the left side of the aorta. The left renal vein normally passes anterior to the aorta but may pass dorsal to it or encircle it. Variations in the connections among the left lumbar veins, the ascending lumbar vein, and the left renal vein are frequent and can be very troublesome in the dissection of the proximal left aortic nodes, with unexpected bleeding.

### Transperitoneal Technique by Laparotomy

The optimal aortic node dissection requires a midline vertical incision extended several centimeters above the umbilicus, often to the xiphoid to obtain adequate exposure to the level of the renal vessels, which is the upper limit of the dissection.

**Step 1: Peritoneal Incision and Exposure of the Area of Dissection**

The extension of lymphadenectomy is the same regardless of the surgical approach: by laparotomy or by a minimally invasive technique, either transperitoneal or retroperitoneal.
The peritoneum is incised at the mesenteric roof from the ileocolic valve to the angle of Treitz at the duodenojejunal flexure (Fig. 13.6). The exposure of the retroperitoneum is obtained by mobilizing the right colon, cecum, terminal ileum, and duodenum from the anterior leaf of Gerota fascia and retracting them laterally along with the ureter and ovarian vessels. Gentle traction across the incision line helps to develop the plane of dissection between the peritoneum and the retroperitoneal structures (Fig. 13.7).

In the region of the cecum and terminal ileum, special attention needs to be paid to avoid ureter damage when the peritoneum is incised. The small bowel is displaced upward to the right (or placed on the chest in a plastic bag) while the sigmoid colon is retracted downward to the left. The ureter and ovarian vessels are not mobilized with the bowel.

**Step 2: Removal of the Paracaval Nodes**

The plane between the fat tissue medial to the kidney and the nodal tissue along the lateral side of the vena cava identifies the lateral margin of the node dissection. The right ureter runs lateral to the vena cava and the paracaval nodes (Fig. 13.8). Similarly, the plane between the psoas muscle and the right common iliac vein is developed. The ureter is retracted laterally after it is separated from the paracaval nodal tissue. The ovarian vessels, previously ligated, are mobilized and clamped.

A retractor is placed under the peritoneum in the superior part of the incision, displacing the duodenal loop from the aorta and vena cava; a retractor is placed laterally to keep the right ureter out of the operative field. The dissection begins by dividing the fatty tissue and the areolar sheath over the right common iliac artery. The dissection progresses cranially up to the point where the left renal vein crosses over the aorta. The sheath is dissected off the artery toward the adjacent vein. The insertion of the right ovarian vein into the inferior vena cava is usually found 1 to 2 cm below the level of the right renal vein, and it needs to be ligated to obtain better access to the upper paracaval nodes.

In this dissection, care must be taken to avoid tearing a fairly constant small vein passing from the fat pad to the mid or medial side of the vena cava. Removing the retrocaval nodes as well as the retroaortic nodes can be necessary in cases of nodal metastases that may be adherent to the vessel wall.

After completion of the previously described dissection, three or four lumbar veins and the corresponding right lumbar arteries can be seen. The veins are doubly ligated and transected on each side of the vena cava. The vena cava can then be displaced laterally and medially and elevated for removal of the nodal tissue dorsal to it. Any residual aortocaval nodes are removed at this time.

The right lumbar arteries are then ligated and divided to prepare for the retroaortic nodal dissection, which will be carried out after completion of the left aortic node dissection.

---

**FIG. 13.6** Incision on the mesentery roof to approach the retroperitoneal space.

**FIG. 13.7** Initial view of the retroperitoneum.

**FIG. 13.8** Dissection of the paracaval space.
Step 3: Removal of the Paraaortic Nodes

To expose the left-side aortic nodes, the inferior mesenteric artery (IMA) is identified by dissecting across the aorta just proximal to its bifurcation and then onto the left common iliac artery. The space under the IMA is enlarged by blunt dissection, and a retractor is inserted (Fig. 13.9). The IMA, which is now behind the retractor, is elevated to expose the left side of the aorta and the left common iliac artery.

The plane is developed between the node packages along the left side of the aorta, the mesentery of the descending colon ventrally, and the psoas muscle laterally. The left ureter and ovarian vessels must be identified and retracted laterally from the border of the dissection (Fig. 13.10).

The origin of the IMA is exposed by further dissection along the aorta. The degree of mobility of the IMA varies, and in some cases, this approach to the left side does not provide satisfactory exposure. In that case the IMA is divided at its origin (Fig. 13.11). In some cases the presence of bulky nodes encasing the IMA or in proximity to it makes an adequate and safe removal impossible without sacrifice of the IMA. In these situations, adequate blood flow needs to be maintained. In order to ensure it, the IMA should be ligated at its origin. In older patients with severe comorbidities or vasculopathies, the color and blood flow of the sigmoid colon can be checked after the IMA is clamped and vascular flow is confirmed with a Doppler probe. After the blood flow is confirmed and/or the color of the bowel is satisfactory, the IMA can be safely transected.

The infrarenal aortic nodes are exposed on the left side by continuing the dissection along the ventral surface of the aorta until the left renal vein is encountered. The mesentery of the descending colon is separated from the retroperitoneal tissues and Gerota fascia to identify the left ureter and ovarian vessels cephalad to the IMA. The ureter is retracted laterally, completing the delineation of the left border of the aortic node dissection.

The left ureter and ovarian vessels must be separated from the mesocolon to remain in the retroperitoneal position. After the retractors are adjusted to expose the left paraaortic region, a plane is developed between the thick node-containing fat tissue and the left common iliac artery. The dissection is carried down to the vertebral bodies and extended distally to the midpoint of the common iliac artery, at which point the nodal tissue is clipped and transected.

The nodal tissue is elevated and bluntly dissected from the vertebral bodies, working cephalad to the level of the IMA (Fig. 13.12).

Before the dissection of the nodal tissue is resumed, the left renal vein and the cephalad part of the left ovarian vein are dissected to identify the confluence of the two veins. The nodal tissue is elevated by further posterior dissection and then transected at its upper end to the inferior margin of the renal vein. In this part of the dissection, care must be taken because there may be one or more tributaries to the inferior margin of the left renal vein, such as the lumbar vein and ascending lumbar vein.
Removal of the retroaortic nodes is performed after the left-side aortic node dissection has been completed. The left lumbar arteries are clamped, ligated, and transected as previously done for the right lumbar arteries to manipulate the aorta and to allow removal of the retroaortic nodes. Care must be taken not to injure the middle sacral artery, which originates from the posterior aspect of the aorta, 1 to 2 cm from the bifurcation.

**Step 4: Removal of the Node Specimen Between the Aorta and the Vena Cava**

The final step is the removal of the lymph nodes between the two vessels. To complete this step, with a vascular retractor, lateralize the aorta and the vena cava; the tissue is dissected and removed. Special attention needs to be paid during this process to avoid damage to the lumbar veins, which are located in the depth of the space between the aorta and the vena cava. The peritoneum over the aorta and vena cava does not need to be closed.

**Pelvic Surgery for Advanced Ovarian Cancer: Surgical Technique**

Three types of radical oophorectomies for advanced ovarian cancer have been described, according to the extension of removal of pelvic organs. Type I includes resection of the internal genital organs and the pelvic peritoneum. It can also involve a full-thickness segmental wedge-shaped resection of the anterior wall of the sigmoid colon. Type II includes, in addition, the rectosigmoid colon resection. Type III consists of a type I or II en bloc resection with a portion of urinary bladder and/or pelvic ureter. Type II radical oophorectomy is by far the most frequent procedure, performed in over 75% of cases.

**Surgical Technique**

After inspection of the tumor distribution in the pelvis, the disease is circumscribed and included within a circumferential incision of the pelvic peritoneum. The incision usually starts at both paracolic gutters, which are cranially prolonged up to the splenic and hepatic angle of the transverse colon. Caudally, the peritoneal incision progresses bilaterally toward the symphysis pubis. Thus the en bloc radical oophorectomy is performed in centripetal fashion.

The ureters and gonadal vessels need to be identified bilaterally. The latter are ligated with sutures such as 2-0 delayed absorbable suture; the ureters are marked with vessel loops for better identification during the procedure (Fig. 13.13). Both round ligaments are identified, coagulated, and divided at 2 cm from the pelvic wall. The lateral avascular spaces of the pelvis are then developed as described earlier. At this point, both uterine arteries can be ligated at their origin in the internal iliac artery to decrease bleeding later, during the dissection. The anterior peritoneum is grasped with clamp rings or Allis forceps aimed to perform the dissection of the anterior pelvic peritoneum from the bladder. The dissection progresses caudally with use of scissors or an electrosurgical unit until a 2- to 3-cm section of the anterior vaginal wall is exposed (Fig. 13.14). Both ureters are dissected from the uterosacral ligaments, and they are caudally tunneled and separated from the uterine arteries with a right angle clamp and sutures (Fig. 13.15).
The retrograde hysterectomy is then performed by creating an anterior colpotomy (Fig. 13.16). This step can be facilitated by the introduction of a gauze pad into the vagina during a bimanual examination. The colpotomy progresses laterally, and the uterine arteries are ligated and divided. Then the posterior vaginal wall is divided and the rectovaginal space is dissected (Fig. 13.17).

**Type I Radical Oophorectomy**

Type I radical oophorectomy is performed in cases of isolated peritoneal implant in the cul-de-sac without major involvement of the sigmoid colon. The peritoneum of the cul-de-sac is dissected from the rectosigmoid, with care taken to avoid incidental injury of the rectal or sigmoid colon wall. Even though sharp dissection is preferred, the right angle forceps and an electrosurgical unit are sometimes needed to complete the dissection. If the sigmoid colon is partially open, interrupted stitches with 2-0 delayed absorbable sutures can be used to close the defect. Some surgeons suggest that the extension of the defect does not need to be larger than 2 cm to proceed with a primary suture; otherwise, a bowel resection should be performed. A "water test" (insufflation of the rectum and colon while the pelvis is filled with sterile water) should be performed to rule out unrecognized bowel perforation.

**Type II Radical Oophorectomy**

Type II radical oophorectomy is performed in cases of obliteration of the cul-de-sac with involvement of the sigmoid colon by the pelvic tumor. Therefore it includes the en bloc resection of the pelvic tumor with the sigmoid colon. The rectosigmoid resection is classified according to the distance between the anal margin and the cranial margin of resection in three categories: high (>11 cm), low (7–11 cm), or very low (<7 cm). A step-by-step type II radical oophorectomy is described in Box 13.2.

In these cases, after the dissection of the rectovaginal space following the posterior colpotomy, the anterior wall of the rectum is identified by the dissection of the mesorectal tissue with the use of the right angle forceps. The proximal margin of the sigmoid colon is divided 2 to 3 cm above the most proximal extent of gross tumor. This step is commonly performed with a gastrointestinal anastomosis (GIA) automated stapling device (4.8 mm). Two rows of staples on either side of the divided colon are placed, avoiding fecal contamination. The sigmoid mesentery is then divided toward the iliocecal angle after the identification and lateralization of both ureters (Fig. 13.18). This step can be performed with a vessel sealing device or with suture ligation. The superior rectal vessels are identified and ligated separately. The presacral avascular space is dissected caudally up to the pelvic...

---

**Box 13.2 Step-by-Step Type II Radical Oophorectomy**

1. Opening lateral pelvic peritoneum
2. Ureter identification
3. Gonadal vessel’s ligation
4. Section of the sigmoid colon
5. Sigmoid mesocolon resection with the inferior mesenteric artery
6. Lateral peritoneum dissection
7. Dissection of the anterior peritoneum from the bladder
8. Ureter dissection from the uterine artery
9. Dissection of the presacral space
10. Retrograde colpotomy-hysterectomy
11. Dissection of the rectovaginal space
12. Dissection of the pararectal fat tissue
13. Rectal resection
14. Colorectal anastomosis
floor musculature (Fig. 13.19). The rectal wall is circumferentially exposed by dissecting the mesorectal tissue with the right angle forceps and vessel sealing device (Fig. 13.20). At this point the lateral ligaments of the rectum, which contains the hemorrhoid vessels, are identified and ligated, allowing additional mobilization of the specimen by detaching the rectum–sigmoid colon junction from the lateral pelvic wall. Once the rectal wall has been cleared of surrounding tissue, the rectosigmoid colon is caudally divided 2 to 3 cm distal to the lowest extent of tumor. This step is usually performed with a curved cutter stapler, which adds two rows of staples on either side of the divided bowel (Fig. 13.21).

**Bowel Anastomosis**
The intestinal continuity is commonly reestablished with an automated stapling device or with a hand-sewn technique (Fig. 13.22). The different techniques are explained in detail in Chapter 17.

**Type III Radical Oophorectomy**
Type III radical oophorectomy, which includes partial ureterectomy or cystectomy, is a very rare procedure at the time of radical oophorectomy for advanced ovarian cancer. However, it can be necessary in cases of cytoreduction with relapsed ovarian cancer. Partial cystectomy can be required when the pelvic peritoneum is dissected from the bladder. In this case, a monolayer running suture can be placed with delayed absorbable 2-0 suture. The introduction of methylene blue solution into the bladder can help to confirm the integrity of the suture and identify unrecognized bladder perforations at the time of the dissection.
Partial ureterectomy is very rare. The pelvic tumor usually compresses the ureters but rarely infiltrates the ureteral wall. However, even with careful dissection, sometime a partial ureterectomy is necessary to remove the tumor. In these cases, a ureteral stent (6F or 7F double-J) needs to be introduced. This procedure can be performed by opening the bladder roof and introducing the stent under direct visualization, through the ureter, in a cranial direction, or it can be introduced under cystoscopic guidance. Then, interrupted seromuscular stitches of 3-0 delayed absorbable suture are placed. The stent can be removed cystoscopically 2 to 3 months after operation.

References
Radical cytoreduction consists of complex surgical procedures that may include extended peritonectomy, diaphragmatic resections, lymphadenectomy, and multiple visceral resections. As a result, it may be difficult to determine which of these innumerable procedures contributes to a specific complication. Patients undergoing cytoreductive surgical procedures are predisposed to predictable major morbidity, and this may be accentuated by their general medical condition and comorbidities. Perioperative planning in accordance with updated evidence-based guidelines should be implemented for every patient scheduled for a cytoreductive surgical procedure. This chapter focuses on the details of a comprehensive preoperative patient assessment and prevention and efficient management of related complications.

**Complication Classification Systems**

Patients undergoing cytoreductive surgery may be predisposed to intraoperative injuries, which occur in approximately 10% of procedures. Current data show that 17% to 63% of patients will develop complications of various levels of severity in the first 30 days after operation.\(^1\)\(^-\)\(^4\)

Historically, the first system developed for grading postoperative complications was the Clavien-Dindo classification. The revised system ranks complications into five categories based on the therapy required to correct the complication and whether the complication is life-threatening or causes subsequent disability (Table 14.1). Under this classification, grade I and II complications are those that require medical treatments. Grade III complications consist of those requiring surgical, endoscopic, or radiologic intervention. Grade IV complications are those that are life-threatening and require an intensive care unit admission or any complication requiring prolonged intubation or reintubation. Death is considered a grade V complication.\(^5\)\(^,\)\(^6\) Chi and co-workers published a scoring system for grading secondary events associated with surgery. Grade 1 complications are those requiring oral medications and/or bedside interventions. Grade 2 complications are those requiring intravenous medications, transfusions, or parenteral nutrition. Grade 3 complications are defined as those requiring reoperation, a radiologic or endoscopic therapeutic procedure, or intubation. Residual disabilities are categorized as grade 4 complications, and deaths as grade 5.\(^7\) The major difference between the two scoring systems concerns the fourth grade (grade IV, life-threatening complications in the Clavien-Dindo classification, and grade 4, residual disabilities in the grading system developed by Chi and colleagues). Use of scoring systems such as the National Cancer Institute Common Terminology Criteria for Adverse Events is possible but probably less appropriate in the context of surgery because they were developed for grading adverse events associated with the use of a medical treatment or procedure.

Minor events (grades I and II according to the Clavien-Dindo classification and grades 1 and 2 according to Chi and colleagues) are the most common types of complications and account for approximately two-thirds of all complications. In the currently reported data, the incidence of major morbidity (grades III and IV or 3 and 4) ranges between 2.5% and 27%, if all events occurring within the first 30 days after operation are considered. Medical complications, with the exclusion of infectious disease, occur in 10% to 18% of patients and include myocardial infarction, cerebrovascular accident, acute organ failure, and thromboembolism.\(^4\)\(^,\)\(^6\)\(^,\)\(^8\) Infections occur in 7% to 10% of patients.\(^1\)\(^,\)\(^9\)\(^,\)\(^10\) Although a rare complication, patients may die from immediate postoperative complications.\(^7\)\(^,\)\(^11\)\(^,\)\(^12\)

The length of hospital stay is prolonged beyond 8 to 10 days in approximately 25% of patients owing to postoperative-associated morbidity.\(^6\)\(^,\)\(^9\) Recently there has been increasing emphasis on the assessment of quality of life after a surgical procedure, and maintenance of quality of life should be a major priority when one is considering patients for cytoreductive procedures. Several tools are available for assessing quality of life after an operation. The ovarian cancer–specific quality-of-life questionnaire (QLQ-OV28) developed by the European Organisation for Research and Treatment of Cancer (EORTC) as a supplement to the validated core QLQ-C30 is one of the more commonly used tools in assessing quality of life after cytoreductive surgery. It consists of an assessment of general health, appetite, sleep, pain, digestive and respiratory disorders, and body image.\(^13\)
complications and the complexity of intraoperative and postoperative medical care. The current literature shows that more than 80% of candidates for cytoreductive surgery have an ASA score of II or III. The Eastern Cooperative Oncology Group (ECOG)/World Health Organization (WHO) Performance Status and Charlson Comorbidity Index are also accurate in predicting morbidity, mortality, and length of hospital stay, but their importance with regard to risk adjustment models is probably less pronounced.

Preoperative comprehensive assessment of associated comorbidities and visceral functions is crucial because it allows patients at high risk for complications to be properly selected, to receive preoperative optimization, and to undergo intensive nursing and close monitoring.

Patients with a history of cerebrovascular disease, cardiac ischemia, arrhythmia, or valvulopathy and those with chronic bronchitis and pulmonary obstructive disease, asthma, or emphysema are at high risk for postoperative decompensation and subsequent major complications. In patients with compromised respiratory function secondary to pleural effusion, one may consider pleural drainage, pleuroscopy, and talcum pleurodesis. Diabetes increases the risk of postoperative infection, particularly of the surgical site, in addition to the risks of postoperative exacerbation and worsening of already existing end-organ damage. Patients with renal or liver disease may also present challenges with regard to the risk of postoperative complications. Anemia is associated with increased risk of postoperative morbidity and mortality. This is related in part to the fact that in patients with preexisting anemia, the physiologic compensatory mechanisms are already activated. Therefore, capacities of adaptation to an acute perioperative anemia are reduced, particularly in the presence of associated cardiovascular or respiratory impairment. Additional risks are iatrogenic and inherent to intraoperative blood transfusion, which is typically recommended in cases of acute hemorrhage regardless of its severity and of the patient's condition. Preoperative correction of anemia may decrease these risks.

Coagulopathies are also a factor to consider in patients with advanced ovarian cancer. The major mechanism involved is a humoral-mediated paraneoplastic syndrome, but other factors such as tumor burden, chemotherapy, surgery, and acute blood loss may trigger coagulation abnormalities. The risk of thromboembolism is significant in patients with ovarian cancers, and up to 20% will develop thromboembolic events. Patients with preexisting deep vein thrombosis or pulmonary embolism are at high risk for postoperative mortality. In those who require inferior vena cava filter placement because of contraindications of anticoagulation or recurrence of pulmonary embolism despite optimal anticoagulation, postponement of the operation should be considered.

Malnutrition is ubiquitous in patients with advanced ovarian cancer, principally because of the mechanical compressive effect of ascites and tumor masses on the digestive tract. In some cases, the bowel is obstructed by invasive carcinomatosis lesions or is affected by motility disorders. Other cancer-related factors such as anorexia and cachexia may also be implicated. Preoperative assessment of nutritional status based on estimation of weight loss and levels of serum albumin, prealbumin, and transferrin is necessary to identify severely malnourished patients (weight loss >10%, albumin level <30 g/L, prealbumin level <10 mg/dL). These patients are known to be at high risk.

### Preoperative Risk Assessment for Complications

Candidates for cytoreductive surgery should be assessed before operation to evaluate risk factors based on age, general medical condition, and comorbidities. This will help the surgeon determine who is the ideal candidate for such a procedure.

Patient age is a key factor in predicting postoperative complications. In fact, patients aged 75 years or older have been shown to have a twofold higher risk of postoperative morbidity and prolonged hospitalization than younger patients. Similarly, the mortality risk is up to 10 times higher in this patient population. Chronologic age alone is not reliable when determining risk estimation, and several scoring systems should be used. The most commonly used scoring system is the physical status classification of the American Society of Anesthesiologists (ASA). This classification consists of a validated risk adjustment score for both general and cytoreductive surgery. Risks of morbidity and mortality are known to be two to four times greater for patients with an ASA score of III or IV. However, there are conflicting data regarding the value of this system in determining with accuracy the risk of intraoperative complications.

### TABLE 14.1 Clavien-Dindo Classification of Surgical Complications

<table>
<thead>
<tr>
<th>Grades</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade I</td>
<td>Any deviation from the normal postoperative course without the need for pharmacologic treatment or surgical, endoscopic, or radiologic interventions. Allowed therapeutic regimens are antiemetics, antipyretics, analgesics, diuretics, and electrolytes and physiotherapy. This grade also includes wound infections opened at the bedside.</td>
</tr>
<tr>
<td>Grade II</td>
<td>Requiring pharmacologic treatment with drugs other than those allowed for grade I complications. Blood transfusions and total parenteral nutrition are also included.</td>
</tr>
<tr>
<td>Grade III</td>
<td>Requiring surgical, endoscopic, or radiologic intervention. Intervention not under general anesthesia. Intervention under general anesthesia.</td>
</tr>
<tr>
<td>Grade IV</td>
<td>Life-threatening complication (including CNS complications) requiring IC or ICU management. Single-organ dysfunction (including dialysis). Multiorgan dysfunction.</td>
</tr>
<tr>
<td>Grade V</td>
<td>Death of a patient.</td>
</tr>
</tbody>
</table>

Suffix d: If the patient has developed a complication at the time of discharge, the suffix d (for disability) is added to the respective grade of complication. This label indicates the need for follow-up to fully evaluate the complication.

### Notes

1. Brain hemorrhage, ischemic stroke, subarachnoid bleeding, but excluding transient ischemic attacks (TIAa).

for postoperative morbidity and mortality, particularly in relation to infectious complications. The published literature shows that approximately 17% of patients scheduled for cytoreductive surgery have albumin levels below 35 g/L. The impact of low levels of albumin and prealbumin on the risk of complications was assessed in ovarian cancer cytoreduction by Geisler and colleagues. Their results showed that patients with prealbumin levels lower than 10 mg/dl have a 10-fold higher risk of major morbidity than those with higher levels (60% vs. 6%, respectively). The risk of bowel anastomotic leak is seven times higher if the serum albumin level is below 30 g/L. Other studies have shown that serum albumin is unequivocally the strongest predictor of postoperative adverse outcomes.

Several studies have reported an upward trend in the risk of major postoperative morbidity in patients with large volume ascites. However, none has shown statistically significant results.

Obesity seems to not be correlated with additional major morbidity with the exception of the substantial risk of surgical site infection. Smoking is correlated with a high risk of postoperative complications. Noxious pulmonary effects of smoking are known to be reversible after 4 weeks of cessation, but there is no evidence of a subsequent decrease in postoperative morbidity risks. Chronic alcohol intake increases the risk of perioperative complications as a consequence of its deleterious effect on the functions of cardiac, hepatic, coagulation, and immune systems. Alcohol cessation at least 4 weeks before operation is associated with a decrease in postoperative morbidity, but there is no evidence of a beneficial effect on mortality risk.

The timing of the cytoreductive procedure also affects the rate of perioperative complications. Data from prospective studies indicate that interval debulking procedures are associated with lower rates of perioperative complications. Rates of morbidity and mortality are lower, with decreases in blood loss, length of hospital stay, and median time to start of operative chemotherapy in comparison with primary cytoreduction. Major complications occur in approximately 6% of cases after interval cytoreduction versus 22% after up-front procedures.

### Surgical Complexity Scores
The rate of postoperative complications is directly related to the surgical extent and the number of visceral resections. Published studies have demonstrated that patients undergoing more than three extended procedures have a threefold to fourfold higher risk of adverse outcomes compared with those who do not undergo any extended procedure. One of the strategies to determine the extent of the procedure has been the development of surgical complexity scores that allow surgeons to gain an objective sense of the aggressiveness of the procedure. In a study by Aletti and colleagues, the authors proposed a surgical complexity score specifically for cytoreductive surgery in ovarian cancer; 1 to 3 points are assigned to every procedure performed during the operation, and points are then added, allowing categorization as low-, intermediate-, and high-complexity operations (Table 14.2).

### Surgical Procedures as Predictors of Perioperative Complications
Lymphadenectomy is reported to be performed in 33% to 40% of cytoreductions, which may be explained by the persistent controversy concerning its therapeutic value in patients without bulky lymph node disease, in addition to the substantial number of recurrences in patients who already received lymphadenectomy during up-front or interval surgery. In other studies, authors reported lymphadenectomy rates of up to 83.6%. Lymphadenectomy is associated with risks of intraoperative vessel injury (4%) and postoperative lymphocyst (13%).

Extensive upper abdominal procedures are frequently performed (27%–38%) during primary cytoreductive surgery. Diaphragm peritonectomy, possibly associated with full-thickness resection, is the most common; it is performed in 13% to 35% of cases. Hepatobiliary resections may be required in the rare cases with true parenchymal involvement. Approximately 1.5% to 10% of patients undergo hepatic complex procedures. A splenectomy is performed in up to 36% of patients. Splenectomy is associated with distal pancreatectomy in 0.5% to 4% of cases. Resections of tumor or lymph nodes from the porta hepatitis or celiac area are reported in approximately 0.2% to 5% of cases, whereas gastric resection is required in less than 0.5% of cases. Data from the literature show that extensive upper abdominal procedures increase the mean operative time by 1.5 times, the mean blood loss by 2 times, and the rate of intraoperative transfusion by 6 times. However, none of these studies found a significant increase in the postoperative morbidity and mortality in relation to such procedures. In these patients, major complication rates are 6% to 22%, and approximately 60% of patients are hospitalized for 5 to 10 days.

Bowel resections are performed in 30% to 50% of primary debulking operations. Approximately one-third of them include multiple digestive tract resections including large bowel, small bowel, or both. Bowel resections increase operative time and blood loss and are associated with prolonged hospital stay and a substantial risk of major morbidity, particularly if there are multiple resections. Bowel resections including only the small intestine are performed in 5% to 20% of patients, and data from several studies show that such procedures do not increase the risk of postoperative morbidity or mortality after cytoreductive

### TABLE 14.2 Surgical Complexity Scoring System Proposed by Aletti and Colleagues

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAH-BSO</td>
<td>1</td>
</tr>
<tr>
<td>Pelvic peritoneum stripping</td>
<td>1</td>
</tr>
<tr>
<td>Abdominal peritoneum stripping</td>
<td>1</td>
</tr>
<tr>
<td>Omentectomy</td>
<td>1</td>
</tr>
<tr>
<td>Pelvic lymphadenectomy</td>
<td>1</td>
</tr>
<tr>
<td>Paraortic lymphadenectomy</td>
<td>1</td>
</tr>
<tr>
<td>Small bowel resection/s</td>
<td>1</td>
</tr>
<tr>
<td>Large bowel resection</td>
<td>2</td>
</tr>
<tr>
<td>Rectosigmoidectomy</td>
<td>3</td>
</tr>
<tr>
<td>Diaphragm stripping or resection</td>
<td>2</td>
</tr>
<tr>
<td>Splenectomy</td>
<td>2</td>
</tr>
<tr>
<td>Liver resection</td>
<td>2</td>
</tr>
<tr>
<td>Complexity Score Groups</td>
<td>Total</td>
</tr>
<tr>
<td>1 (low)</td>
<td>≤3</td>
</tr>
<tr>
<td>2 (intermediate)</td>
<td>4–7</td>
</tr>
<tr>
<td>3 (high)</td>
<td>≥8</td>
</tr>
</tbody>
</table>

*TAH-BSO, Total hysterectomy and bilateral salpingo-oophorectomy.*
Large bowel resections are performed in 10% to 41% of patients and consist frequently of rectosigmoid resection (5%–14% of cases). Total or subtotal colectomy is performed in 3.2% of patients. Large bowel resections increase the risk of major complications by three times, but there is no evidence that there is an associated increase in the mortality risk. Urinary tract resections are performed in 0.1% to 3% of cytoreductions and consist frequently of partial cystectomy and/or ureterectomy.

Selection of Patients for Surgery

In accordance with 2016 guidelines from the European Society of Gynaecological Oncology (ESGO), a comprehensive preoperative assessment by an expert multidisciplinary team is recommended in order to select patients with unresectable disease and those who can be debulked up-front to no residual tumor but with reasonable morbidity, taking into account their performance status and comorbidities. When patients have been appropriately evaluated and considered ideal candidates for surgery, then all details of the procedure and the intended approach should be discussed at length. If a patient is not deemed an ideal candidate for surgery, then all the appropriate measures should be taken to address the issue of concern and proceed with neoadjuvant chemotherapy to treat the primary disease.

Preoperative Care Planning and Prevention of Complications

According to the Enhanced Recovery After Surgery (ERAS) Society guidelines, correction of severe anemia (hemoglobin levels <7 g/dL) is recommended before operation. Iron deficiency and other underlying disorders should be corrected to improve a patient’s response to the intraoperative hemorrhage and avoid or at least minimize the need for perioperative transfusions. Glycemic control should also be optimized and includes preoperative oral carbohydrate loading to improve preoperative well-being and reduce postoperative insulin resistance.

Thromboembolic Prophylaxis

In accordance with ERAS guidelines, patients with preexisting deep vein thrombosis or pulmonary embolism who are on anti-coagulation must be transitioned to heparin-based anti-coagulation. Operation should be delayed for at least 1 month after the diagnosis of a thromboembolic event. For other patients, venous thromboembolism prophylaxis including the obligatory use of a pharmacologic agent is recommended despite an associated increase in the risk of bleeding. Low-molecular-weight heparin with the highest prophylactic dose (enoxaparin, 40 mg; dalteparin, 5000 IU) or, alternatively, low-dose unfractionated heparin (5000 IU) should be administered 12 to 2 hours before operation (12–10 hours if a neuraxial anesthesia/analgesia is planned and 4–2 hours otherwise). In addition, use of gradient compression elastic stockings or intermittent pneumatic compression devices is recommended and should be continued during the operation.

Nutritional Support

Support with oral and/or parenteral nutrition should be recommended for severely malnourished patients (weight loss >10%, albumin level <30 g/L, prealbumin level <10 mg/dL). Monitoring of nutritional status may be performed on the basis of clinical and laboratory test results. Patients should undergo surgery with prealbumin levels higher than 10 mg/dL.

Smoking and Alcohol Cessation

In accordance with ERAS guidelines, physical activity is encouraged, along with cessation of smoking and alcohol intake at least 4 weeks before surgery.

Preoperative Antibiotics

Preoperative administration of antibiotics is recommended because it is correlated with a decrease in the risk of surgical site infection. Use of third-generation cephalosporins or clindamycin is accepted. Additional doses may be required in obese patients and in prolonged procedures, in particular when duration exceeds two half-lives of the antibiotic used.

Postoperative Care Planning

Intensive Care Unit Hospitalization

Ten percent to 30% of patients require immediate postoperative intensive care hospitalization. During this period, repetitive clinical assessment is the cornerstone of monitoring. Routine use of laboratory tests should be rationalized with targeting of disorders related to expected or suspected complications. These studies are crucial primarily to exclude extremely serious complications such as disseminated intravascular coagulation, acute respiratory distress syndrome, or systemic inflammatory response syndrome (SIRS), particularly in the context of intraoperative significant hemorrhage, severe visceral failures, and intensive resuscitation.

Glycemic Control

Postoperative hyperglycemia is associated with parenteral infusion and nutrition. Optimization of glycemic control is crucial because it is correlated with a decrease in infectious morbidity and mortality risks.

Fluid Management

Fluid management requires a comprehensive evaluation of losses and fluid shift. The third space phenomenon is common and is characterized by accumulation of fluids in the peritoneal and pleural cavity. Albumin administration may be useful if profound hypoalbuminemia (<2 g/dL) is present. Use of diuretics may be required in patients with delayed transcellular fluid clearance and/or inadequate diuresis. According to ERAS guidelines, optimal management should take into account cardiac and renal functions in order to avoid fluid overload and maintain normovolemia and diuresis. Major blood pressure fluctuations should also be avoided to prevent vital organ ischemia or hemorrhage.

Maintenance of Electrolyte Homeostasis

Hyponatremia is frequently observed in the postoperative period owing to hypovolemia or extended administration of crystalloid solutions. Correction of hyponatremia should be tailored to how soon it occurs and the presence of clinical neurologic signs. Prompt and controlled correction based on normal or hypertonic saline administration or fluid restriction is recommended.

Prolonged gastric aspiration may cause hypernatremia, metabolic alkalosis, and hypokalemia. In this case, fluid resuscitation should be preferentially based on use of lactated Ringer solutions because they contribute to compensation of
alkalosis.\textsuperscript{2} Correction of hypernatremia should be progressive and controlled. Hypokalemia should also be corrected because it may contribute to sustained ileus.\textsuperscript{2}

**Nutritional Support**

Extended digestive tract resection, postoperative ascites production, and fasting may result in malnutrition. Current guidelines from the ERAS Society recommend removal of the gastric tube before the end of operation and early feeding.\textsuperscript{18} Pearl and colleagues,\textsuperscript{33} in a study of 110 abdominal surgical procedures for gynecologic malignancies, demonstrated that there is no significant difference in terms of digestive tract complications, rapidity of bowel function recovery, and hospital discharge between patients receiving intraoperative orogastric tubes and those receiving postoperative nasogastric tubes.

Early enteral nutrition was specifically assessed in major surgery for gynecologic malignancies. Results showed a decrease in the time to passage of flatus and stools and a subsequent rapid discharge.\textsuperscript{2,32} However, 10% of patients managed accordingly will develop major abdominal distention and emesis and will require secondary nasogastric tube insertion.\textsuperscript{18}

Several studies have suggested that use of chewing gum may reduce postoperative ileus. Recent data from clinical trials involving colorectal surgical procedures indicate limited clinical improvement, but because none of these studies have reported adverse impacts, the use of chewing gum should be encouraged until further data are available, in particular for ovarian cancer surgery.\textsuperscript{33}

Parenteral nutritional support is reserved for malnourished patients when enteral feeding is expected to be delayed. Patients receiving exclusive parenteral nutrition should be monitored for detection of iatrogenic metabolic disorders, and transition to enteral feeding should be performed as soon as possible.\textsuperscript{2}

**Correction of Anemia**

There is a controversy concerning the usefulness of intensive optimization of postoperative anemia. Several studies have shown that there are no significant differences in terms of major morbidity and mortality between patients receiving transfusion as soon as hemoglobin levels fall below 7 to 8 g/dL versus 10 g/dL except in patients with underlying cardiovascular impairments. Transfusion is recommended in patients with poor tolerance or those who will rapidly be directed to receive adjuvant treatment.\textsuperscript{19}

**Pain Management**

Optimal pain management is crucial for the postoperative course because it reduces postoperative stress, hyperventilation, tachycardia, and the subsequent risk of cardiac events, particularly myocardial ischemia.\textsuperscript{34,35} In the immediate postoperative period, intravenous patient-controlled analgesia is commonly used until transition to oral analgesics can be achieved. Use of epidural analgesia was assessed for safety and effectiveness in general abdominal surgery. Data show that its use permits early cessation of intravenous opiate medications and then reversal of respiratory depression, fast restoration of bowel transit and voiding, and, consequently, prompt ambulation and discharge.\textsuperscript{34,35} In addition, authors have reported a decrease in the risks of mortality and major complications such as thromboembolism and pulmonary infectious disease.\textsuperscript{34} There are no available data assessing the use of epidural analgesia in ovarian cancer cytoreductive surgery. Several reports of studies with prospective and retrospective designs that included patients scheduled for open gynecologic procedures have recommended epidural analgesia.\textsuperscript{35} However, one must consider that routine use of epidural analgesia may contribute to fluid overload of the patient in the postoperative period as a response to episodic hypotension.

**Respiratory Management**

Respiratory function is almost always impaired during the postoperative period because of prolonged anesthesia, postoperative bed confinement, and a frequent increase in intraperitoneal volumes.\textsuperscript{2} Noninvasive mechanical ventilation with positive end-expiratory pressure may be required after patient extubation to avoid atelectasis and the subsequent risk of pulmonary infection. Chest physical therapy including airway clearance and deep breathing exercises along with incentive spirometry are the cornerstone of respiratory management in addition to rapid resumption of ambulation.\textsuperscript{2,36}

For diaphragmatic surgery with intraoperative chest tube placement (12%–45% of patients), drainage should be maintained for 2 to 3 days or even longer in case of persistent high outflow and is generally removed when outflow is less than 150 mL/day.\textsuperscript{2,36,37} After diaphragm resection without chest tube placement, oxygen intake should be increased to accelerate pneumothorax resolution. Chest x-ray monitoring is recommended for detection of pleural effusion or residual pneumothorax. Data from several studies indicate that secondary drain placement is necessary in 15% to 20% of patients.\textsuperscript{36,37}

**Postoperative Thromboembolism Prophylaxis**

Pharmacologic thromboembolism prophylaxis should be restarted after postoperative hours 8 to 12, along with maintenance of mechanical methods.\textsuperscript{2} Low-molecular-weight heparin with the highest prophylactic dose (enoxaparin, 40 mg once per day; dalteparin, 5000 IU once per day; tinzaparin, 3500 IU once per day) or, alternatively, low-dose unfractionated heparin (5000 IU three times daily) may be used. In patients who are at significant risk of bleeding, management should be individualized. Prophylaxis should be maintained for a total of 28 days.\textsuperscript{18,21,36}

**Ambulation and Discharge**

Current data show that mean hospital stay is approximately 2 weeks.\textsuperscript{4,27} Rapid resumption of ambulation prevents the risk of respiratory complications and thromboembolism. Its effect on improving postoperative ileus is controversial.\textsuperscript{2} Discharge soon after operation with removal of catheters and drains should be done as soon as appropriate.\textsuperscript{27}

**Perioperative Complications**

Three percent to 7% of perioperative complications necessitate reoperation in the first 30 days after operation, and in up to 15% of patients, invasive radiologic procedures are required. In patients with major complications, up to 90%
require a second surgical procedure, and 28% to 68% of them will need interventional radiology. In patients with complications occurring after hospital discharge, rehospitalization is required in 7% to 19.5%.1,2,6

**Hemorrhage**

Intraoperative complications occur in approximately 10% of patients undergoing cytoreductive surgery; the majority are either vascular or visceral injuries.1 Blood loss during debulking procedures typically ranges from 600 to 800 mL but may exceed 1000 mL in up to 25% of patients.2,3 Intraoperative major hemorrhage (estimated blood loss >20 mL/kg) complicates 7.4% of primary debulking procedures.4

During the early postoperative period, monitoring should be focused on detection of hemorrhage, which may result in hemodynamic impairments, bleeding from drainage, and abdominal distention related to hemoperitoneum. Laboratory tests show acute anemia and possibly a consumption coagulopathy. Postoperative hemorrhage is reported to complicate 3% to 11.5% of cytoreductions.5,9,12 Its management includes correction of anemia and coagulopathy by transfusion in association with restoration of normovolemia by colloid solutions.9 In some cases, reoperation may be necessary to check the peritoneal cavity and for hemostasis control.2,38

**Infection**

Major infectious complications are reported to occur in 7% to 10% of patients.1,2,6 Infections result in significant morbidity with prolonged hospital stay and increased need for intensive care, medications, and invasive procedures or reoperation.9,26 Severe infections with tachycardia or polynepra reflect the presence of SIRS and constitute sepsis, which is reported to occur in 1.6% to 2.1% of patients.27,29 In these cases, a first-line broad-spectrum antibiotic should be promptly initiated, with subsequent tailoring according to bacterial identification results. Several additional drugs modulating immune and coagulation processes such as recombinant activated protein C, antithrombin, or immunoglobulin have been assessed in the field of sepsis. None of them can be recommended because their effectiveness and safety have not been proven.39,40 Severe sepsis with hemodynamic perturbations or organ dysfunction requires correction of hypoperfusion based on fluid resuscitation. Ultimately, multiple organ dysfunction syndrome and septic shock may occur, and use of vasopressor drugs is therefore necessary.39 Whether use of antibiotics should be maintained for a prolonged period should be decided by taking into account the patient’s status, presence of foreign bodies, and bacterial characteristics. Specific management of the infection source is recommended. Antifungals may be required if a fungal infection is strongly suspected or proven.39

**Surgical Site Infection**

Surgical site infections occur in 1% to 21% of cases.2,9,27 Infections related to *Staphylococcus* and *Streptococcus* are the most common. Usual management including antibiotics and wound care is almost always sufficient to ensure healing. Identification of bacteria from the intraabdominal cavity should initiate assessment for an underlying infection. The wound may reopen partially with discharge of infected collection, hematomas, or seromas. Intentional surgical wound reopening may be required for debridement. In general, wound closure is possible and the subsequent course is favorable.2 In the rare patient with a large and deep infection, management may involve the use of a vacuum-assisted closure therapy system with delayed final closure.41

Fascial dehiscence occurs in less than 1% of patients; ascites reaccumulation and malnourishment may be contributory conditions. Fascial dehiscence may pose a management challenge because of the possibility of an underlying intraabdominal infection and because of the risk of evisceration until surgical repair can be achieved. Subsequent risk of incisional hernia remains high despite adequate management.2,27

**Digestive Tract Fistula**

Digestive tract fistula or leakage is frequently related to anastomotic dehiscence, but the etiology includes other causes such as ischemic disorders, unrecognized intraoperative injury, and excision or electroevaporation of tumor implants on digestive tract serosa. Several factors such as malnutrition, prolonged operative time, use of intraoperative chemotherapy, and negative-pressure wound therapy are associated with an increased risk of digestive fistula. Depending on their location in the digestive tract, their cause, and prior drainage, fistulas may cause generalized peritonitis or localized abscess or may manifest with leakage of digestive contents through a wound or a drain or with a urinary or vaginal discharge. In general, computed tomography (CT) scan with ingestion or local administration of a water-soluble contrast agent allows for characterization of the leakage. Therapeutic management may variably include resuscitation, hydration, nutritional support, antibiotics, somatostatin analogues, interventional radiologic procedures, and surgical repair if necessary.

Gastric fistula occurs in less than 1% of patients who undergo cytoreduction.10 Gastric resection, total omentectomy, and postoperative gastric distention may be associated with an increased risk of fistula.2 In general, gastric fistula requires surgical repair. Placement of an ostomy tube distally to the fistula (gastrostomy or, alternatively, jejunostomy) may be proposed for an early enteral feeding. Conservative management may be considered in patients with an indolent clinical presentation. It includes fasting, antibiotic administration, and radiologic drainage placement along with nutritional support.

Pancreatic leak or fistula is reported to complicate 24% of cases after splenectomy with caudal pancreatectomy. Most of the time, transient fistulas have a favorable course, particularly with the use of a somatostatin analogue, which is known to reduce fistula output and the time to fistula closure. Patients with a measurable drainage output that exceeds 30 mL/day after postoperative day 3 and increased amylase levels (more than three times higher than the normal serum levels) are at high risk for subsequent morbidity, particularly infected abdominal collections.42 In these patients, management should include antibiotics, invasive radiologic drainage, and octreotide. Surgical reexploration is rarely required. Oral feeding should be resumed as soon as clinical improvement is observed. Hospital stay is significantly prolonged, and intensive care unit admission may be necessary in patients with subsequent complications such as septic shock and acute respiratory distress syndrome.42
Data from studies of cytoreductive surgery in ovarian cancer and other peritoneal carcinomatosis shows that bowel fistula occurs in 0.5% to 4% of patients. Small bowel fistula rarely leads to peritonitis but underlies important hydration and electrolyte disorders that should be corrected in addition to administration of parenteral nutritional support. Conservative management including adequate drainage, antibiotics, and octreotide is recommended in patients with low-output fistula and no subsequent major impairments. Up to 90% of fistulas close after 4 to 6 weeks. Surgical repair remains necessary in approximately 8%. 

Urinary fistulas are uncommon and occur in less than 0.5% of patients.

### Section 5 Ovarian Cancer

### Gastrointestinal Tract Complications

In general, intestinal function is resumed within 3 days after operation. Ileus that appears or recurs after an initial intestinal transit recovery is a problematic situation. In these cases and in patients with protracted ileus, radiologic examination is recommended to exclude small and/or large bowel obstruction. The literature shows that up to 12% of patients will develop major digestive tract complications, including ileus in approximately 3%. 

### Gastric Distention

Gastric distention is common after abdominal surgical procedures, particularly if omentectomy is included. It may be related to gastroparesis or a consequence of ileus. There are no available data detailing its incidence after cytoreductive surgery for ovarian cancer. However, it is known that approximately 10% of patients managed without postoperative gastric tube and early enteral feeding will develop major gastric distention. Management is based on nasogastric tube placement for aspiration.

### Ileus

Prolonged ileus occurs particularly after procedures including digestive tract resections: 7.8% to 21% after bowel resections and up to 40% after multiple small and large bowel resections. Otherwise, rates of ileus do not exceed 1% to 3%. Most of the time, gastric suction associated with intravenous hydration, correction of electrolyte abnormalities, and eventually parenteral nutrition permit resolution of ileus. The impact of prokinetic drugs, such as erythromycin, has been assessed in the context of postoperative ileus after colorectal surgical procedures, and the results indicate limited improvement.

---

### Ascites Reaccumulation and Abdominal Compartment Syndrome

Postoperative reaccumulation of ascites is a common phenomenon after cytoreductive surgical procedures. Paracentesis should be avoided because it may increase the intravascular depletion associated with postoperative fluid shift. Occurrence of chylous ascites is a rare complication that may occur after lymphadenectomy and necessitates use of a fat-free diet.

Occurrence of abdominal compartment syndrome is a rare and extremely serious complication that may be related to several conditions such as major ascites, hemorrhage, ileus, gastric and/or bowel distention, visceral edema, peritonitis or intraabdominal abscess, shock, and excessive fluid resuscitation. All of these conditions lead to an increase in intraabdominal pressure and poor visceral perfusion. The diagnosis is suggested in the presence of major abdominal distention associated with renal and/or cardiovascular dysfunction and is confirmed by an increase in intraabdominal pressure measured with the trans-vesical technique. Prompt and effective abdominal decompression almost always requires reoperation with immediate or deferred definitive abdominal closure through the temporary use of laparostomy devices. After decompression, patients should be closely followed because a secondary increase in intraabdominal pressure may occur and because of the risk of enterocutaneous fistula related to negative-pressure therapy. Several medical and minimally invasive therapies may be beneficial as temporizing measures before surgical decompression. In some patients, percutaneous catheter drainage may reduce the need for surgery.

### Hematologic Disorders

Hematologic disorders are reported to occur in less than 2% of patients after cytoreduction if chemotherapy side effects and acute anemia related to hemorrhage are excluded. Thrombocytosis is common after splenectomy, but antiplatelet treatment is unnecessary if platelet count does not exceed 1 million per μL. Significance of postsplenectomy leukocytosis is challenging because the physiologic increase in leukocytes may hide an infection-related rise.

### Thromboembolic Complications

Patients undergoing extended pelvic dissections and those with acute intraoperative blood loss are at high risk of venous thromboembolism. Reported rates of deep vein thrombosis after cytoreductive surgical procedures vary widely. Most reports indicate rates ranging from 1% to 10%. Higher rates reaching 20% or 30% have also been reported by some authors. In addition to Doppler ultrasound, CT scan with use of an intravenous contrast agent may be required for assessment of pelvic and caval vein thromboses. D-dimer tests may be useful for making the diagnosis, particularly in cases of negativity, in which thromboembolic disease may be theoretically excluded.

Reported rates of pulmonary embolism range from 1.5% to 16.7%, but this complication is known to be largely undiagnosed. The diagnosis is considered in patients with respiratory failure, chest pain, or, occasionally, less specific symptoms such as dizziness or palpitations and is confirmed with CT pulmonary angiogram. However, up to 70% of CT scans may result in misdiagnosis of pulmonary embolism. Difficulties in diagnosis
Chapter 14 Complications and Management of Radical Cytoreduction

Respiratory Complications

Respiratory dysfunctions are common after cytoreductive surgical procedures and may be related to different and possibly associated causes. Several authors have suggested that diaphragm dysfunction caused by phrenic nerve injury after diaphragmatic peritoneal stripping or full-thickness resection is associated with several respiratory complications. Assessment of the severity of the dysfunction based on arterial blood gas evaluation as well as implementation of specific therapies should be done without delay; respiratory failure occurs in approximately 10% of patients.

Pulmonary Infection

Pneumonia occurs in 3% to 18% of patients and is frequently severe with acute respiratory failure and a substantial risk of mortality. Pneumonia specific to patients who have undergone splenectomy is reported to complicate approximately 5% of cases. Management of pulmonary infections includes prompt use of antibiotics for presumed nosocomial and commonly multidrug-resistant organisms. Monitoring should be focused on prevention and detection of acute respiratory distress syndrome, which may be caused by coagulopathy and transfusion.

Pleural Effusion

Occurrence of pleural effusion is frequent after cytoreductive surgery (9%-59% of patients). Data indicate that it is the most common major complication after diaphragmatic surgery, with an incidence ranging from 40% to 60%, Pleurocentesis with pleural catheter placement is required in up to 15% of patients who undergo diaphragmatic surgical procedures. Effusion drainage should be volume controlled. Approximately 10% of patients undergoing pleurocentesis will develop a pneumothorax and consequently require chest tube placement.

Other Respiratory Complications

Atelectasis is common in the context of cytoreduction. Available data indicate that left inferior pulmonary lobe atelectasis occurs in 16% of patients undergoing splenectomy. Other causes of respiratory failure may result in acute pulmonary edema related to fluid overload or cardiac failure.

Cardiac and Neurovascular Complications

Cytoreductive surgery may cause several hemodynamic imbalances that may not be well tolerated by patients, particularly in the presence of preexisting cardiac comorbidities.

As with other noncardiac surgical procedures, postoperative myocardial infarction occurs in about 0.5% to 2% of patients and up to 6% in those with a history of myocardial ischemia. Cardiac impairment can generally be avoided if an efficient therapeutic management strategy is initiated without delay. One of the challenges in these patients is the imbalance between the need for anticoagulation and the risk of hemorrhage. Data concerning benefits of the perioperative use of β-blockers in the prevention of myocardial infarction, arrhythmias, and mortality are conflicting. Indeed, several studies including noncardiac surgery indicate a possible increase in the risks of hypotension, bradycardia, and stroke with β-blocker use. The risk of stroke is low after cytoreductive surgery and does not exceed 0.5%.

Renal Failure

Approximately 2% of patients undergoing a cytoreductive surgical procedure will have renal failure. Because extended pelvic and retroperitoneal dissection may result in ureteral or bladder injuries and/or dysfunctions, a postrenal cause of acute renal failure should be excluded first. Prerenal hemodynamic mechanisms of failure are the most common. In fact, because of major hemorrhage and/or severe fluid loss and shift, hypovolemia may persist, with inadequate blood pressure and a subsequent risk of ischemic renal injury. The reported incidence of shock does not exceed 2%, and related mechanisms may also include sepsis, cardiogenic factors, or multifactorial conditions. Prerenal failure is most often reversible if prompt management including the punctual use of vasopressor drugs, fluid resuscitation, and optimization of homeostasis is done.

Nephrototoxic injuries are less frequent except in elderly and depleted patients. Dialysis is the ultimate care procedure for renal failure and is restricted to patients with multiple organ impairment, refractory fluid overload, or life-threatening metabolic disorders.

Complications of Intraoperative Hyperthermic Intraperitoneal Chemotherapy

Current data regarding the incidence of severe surgical morbidity after cytoreduction and hyperthermic intraperitoneal chemotherapy (HIPEC) are conflicting. Several authors have
reported rates ranging from 15% to 29% of cases (slightly higher than in procedures without HIPEC). Other studies have reported rates of up to 65% of cases, which led to closure of a number of prospective studies. Rates of reoperation and readmission are approximately the same as those reported after procedures without HIPEC (6% for reoperation and 18% for readmission). Major disparities concerning mortality rates have also been reported, but most studies have indicated rates ranging from 0% to 7%. Hematologic complications are the most common, with severe anemia occurring in up to 40% of cases. Acute intraabdominal bleeding requiring reoperation complicates approximately 18% to 30% of procedures in which oxaliplatin is used as intraperitoneal chemotherapy. Infection risk is also increased compared with procedures without HIPEC (approximately 15% of cases). Metabolic disorders may variably occur depending on the selected chemotherapy regimen. The risk of renal failure, specifically related to the intraperitoneal use of cisplatin, should be avoided by perioperative hydration.

### Mortality

Rates of mortality occurring in the first 30 days after operation and reported in institutional studies range from 0.3% to 3.6%,. Rates from population-based studies are slightly higher and range from 3% to 8%. The most important indicators in prediction of postoperative mortality are age, ASA status, and comorbidity scores. There is no evidence of a prognostic impact on mortality in relation to surgical radicality.

Mortality rates in patients aged 65 years or older range from 11% to 17.5%. Rates of mortality occurring in the first 3 months after operation range from 5% to 20% in patients aged 75 years or older depending on their ASA and comorbidity scores. Increased comorbidity scores are associated with rates of short-term mortality (the first 30 days after operation) ranging from 10% to 19%. Preoperative prealbumin levels below 10 mg/dL are associated with a mortality rate of 23% versus 0% for levels above 10 mg/dL. Similarly, albumin levels below 34 mg/dL are associated with threefold higher mortality than in patients with normal levels. Patients admitted and operated on emergently have a 30-day mortality risk exceeding 20%. Patients with stage IV disease are at increased risk for 30-day mortality.

Among patients with major postoperative morbidity, the highest rate of mortality is observed in the context of severe infections. In these patients, the risk of death increases to 40% in those with septic shock and multiple organ dysfunction syndrome. Mortality may also be related to pulmonary embolism. Risk varies widely and rises to 30% in patients with massive embolism. Data from studies of noncardiac surgical procedures indicate that cardiac complications, principally those related to ischemia, are associated with a death risk of 50%. Abdominal compartment syndrome increases the mortality risk (up to 70%), and this risk remains greater than 50% even after an efficient decompression.

### Conclusion

A comprehensive preoperative assessment for the risks of morbidity, mortality, and compromise in the quality of life in relation to the planned operation should be offered to patients. A multidisciplinary and specialized team with a strict adherence to updated guidelines is recommended in order to reduce the risk of adverse operative outcomes. The rate of perioperative complications will determine the patient’s overall outcome, including implications on quality of life and prognosis.

### References

Pelvic exenteration (PE) is a very complex procedure, even currently. In addition to unique surgical erudition and interdisciplinary surgical team involvement, these operations require special expertise for the right candidate selection, postoperative care, and handling of complications. Because of the narrow spectrum of indications, PE is a rare procedure, and so the only solution for achieving good results is establishing a system of candidate centralization. Such a system requires an excellent interplay among all experts and an agreement among gynecologic oncologic institutions for the referral of candidates to a few centers, which can therefore accumulate sufficient experience.

Achieving this ideal network can be limited by an array of obstacles, such as reluctance of an institution to refer its patients to a different institution; late diagnosis of local progression in patients after primary radiotherapy; consideration of PE after too long an interval after detection of recurrence, often as late as after palliative chemotherapy has been given; or even the unavailability of these procedures in many regions in the world. Results of a survey evaluating the patterns of care in 61 institutions in Germany and the United States were published in 2009. In these two countries, which both have a high quality of care in gynecologic oncology, only four centers carried out more than 10 PEs a year. In the Czech Republic, based on data from the National Oncology Register (NOR) and the National Register of Hospitalized Patients (NRHOSP), PE is performed in only approximately 20% of the assumed number of suitable candidates. In most patients PE is not considered at all.

### History

After more than half a century, tribute still must be paid to the seminal work of Alexander Brunschwig. It was an outstanding achievement to perform such extensive operations in the 1940s, with inaccurate preoperative imaging diagnostics, limited possibilities to control bleeding, a much lower level of intensive care, and inadequate options for urinary tract reconstruction. The first procedures were carried out with palliative intent with an almost 25% intraoperative mortality rate (5 of 22 patients), which should be appreciated as a unique accomplishment at that time. In fewer than 20 years (1947–1965), Brunschwig compiled a large cohort of 925 patients with PE. Taking into account the lack of preoperative imaging at the time, it is not surprising that many of the patients had lymph node (LN) involvement or that no tumor was found in the final specimen from 24 patients. He routinely applied gauze packs in the pelvis and kept them in place for 72 hours. The intestinal fistula formation rate reached 15%, and mortality in the whole series reached 8%. He performed even extremely extensive procedures, which to this day are rarely used and in a few selected institutions, such as external or common iliac artery resection in 11 patients and pelvic bone resection up to the extent of hemipelvectomy in five patients with cervical cancer. The overall survival reached 20%, even in such a heterogeneous and risky cohort.

A major weakness of Brunschwig’s operation was frequent recurrent pyelonephritis and renal failure due to the drainage of ureters to the active part of the colon. The use of the excluded part of the bowel for urinary diversion, which was described by Bricker, introduced a significant improvement. Both ureters were anastomosed into the loop of the distal ileum, which was closed on the cranial end and brought as a urostomy on the opposite end. In patients with previous pelvic radiation, including the ileocecal bowel, the author later described the use of transverse colon.

During its more than 60-year history, PE has undergone many improvements, which, above all, dramatically decreased mortality. New techniques of bleeding control, especially advanced bipolar coagulation, the use of antibiotics, a significant improvement in intraoperative and postoperative intensive care, and new developments in the reconstructive phase of the procedure, contributed to the improvement of outcome. Techniques in pelvic floor and vaginal reconstruction notably decreased the rate of complications caused by empty pelvis syndrome. Other significant enhancements resulted from increased accuracy of preoperative imaging, which facilitates selection of good candidates, and the ability to tailor the extent of the procedure. It should be noted that the basic principles of PE, the surgical technique, and the classification are still described in the same way they were more than 50 years ago by Alexander Brunschwig.
Indications

The most frequent indication for PE is recurrent cervical cancer after primary radiotherapy. Radical surgical treatment is the only modality in this indication with a potentially curative outcome. Vulvar, vaginal, and endometrial cancer represent about one-third of the cases in large series of PE performed for mixed types of malignant gynecologic tumors.\(^6-10\)

Whereas in rectal cancer PE is performed more often in primary treatment, in gynecologic tumors radiotherapy or chemoradiotherapy is mostly preferred. Nevertheless, there are cohorts of patients in whom PE is the treatment of choice in primary treatment, such as patients with pelvic radiotherapy in their history (i.e., lymphoma treatment), patients with locally advanced vulvar or vaginal cancer, or those with a locally advanced tumor and the presence of fistula. The oncologic outcome in cohorts after PE conducted in primary or secondary treatment does not differ.\(^10,11\)

Because of high morbidity, most PEs are performed as therapeutic procedures with the goal of achieving disease cure. In some reports, patients in whom complete resection (R0) was not performed are enrolled into the category of palliative procedures, which is not correct because the decisive factor is the primary intention. The actual use of PE in palliative care with the aim of increasing quality of life is rather rare. In a small group of 18 patients with cervical, vulvar, or endometrial cancer, the mean overall survival after palliative PE was less than 1 year.\(^12\)

Even though the majority of patients were satisfied with the procedure, half of them had major surgical complications. In a different group of mixed pelvic tumor types, there were 14 women referred for palliative PE; four of the procedures were aborted, and the outcome was evaluated as having zero benefit in two patients and excellent or good in eight patients.\(^13\) Although data are limited, it is obvious that the morbidity of the procedure is high even in palliative treatment, so the palliative indications require careful candidate selection and extensive counseling. The main reason for palliative PE is usually uncontrollable symptoms such as intractable pain or severe bleeding.

Classification

One of the main messages of this chapter should emphasize that the extent of PE must always be meticulously individualized, which is crucial on one hand for achieving the best oncologic outcome and on the other hand for minimizing patient morbidity. The majority of complications, particularly severe ones, are caused by a large volume of resected tissue and formation of dead space that cannot be replaced by tissue or material. Close attention should be paid to the preservation of tissue that does not necessarily have to be resected.

The extent of the procedure can be tailored on three planes. It is not only a choice of one of the three basic PE types in a sagittal pelvic plane among anterior, posterior, and total. Equally relevant is the cranio-caudal extent, with the possibility of preserving the vulva, vagina, and urogenital diaphragm. Moreover, the majority of lateral tumors are not located centrally, which enables significant adjustments to the radicality on each side of the pelvis in the frontal plane.

The basic classification distinguishes in the sagittal plane an anterior (including cystectomy and urethrectomy), posterior (including rectosigmoid resection), and total PE (Fig. 15.1). The consequence of an anterior or posterior exenteration is one permanent stoma, and two stomas in the case of total PE. This tentative classification can be modified in many cases. The resection of the sigmoid colon and/or rectum followed by colorectal anastomosis can be sufficient for the achievement of R0 resection. In anterior or total PE, only cystectomy can be performed and the intact urethra used for continent urinary diversion.

In planning for a type of PE, not only the localization of the recurrent tumor should be taken into account but also the extent of the disease before primary treatment (i.e., infiltration to other pelvic structures) and the radiation dose received by the adjacent organs. Previous radiation worsens the quality of the rectal or urinary bladder wall. The dissection of fibrotic rectovaginal or vesicovaginal spaces is associated with a higher risk of fistula formation in the postoperative period. This is a
FIG. 15.2 Types of Pelvic Exenterations in the Coronal Plane. Type I—endopelvic fascia and pelvic diaphragm are preserved. Type IIA—includes resection of levator ani muscle but preserves the urogenital diaphragm and distal vagina. Type IIB—includes vaginectomy. Type III—includes vulvectomy.

Preoperative Imaging

It is necessary to emphasize the three different goals of the preoperative workup: diagnosis of the recurrence, exclusion of distant metastases, and assessment of the local extent of the disease.

Early diagnosis of local pelvic recurrence before it is too advanced or spread is key for the prognosis after PE. Current guidelines for surveillance after primary treatment are generally the same for all patients, irrespective of the risk of recurrence. Imaging studies are usually indicated only in the presence of symptoms or a suspicious finding at physical examination. Positron emission tomography–computed tomography (PET-CT) in routine surveillance is generally considered to be too expensive and not cost-effective.\(^{14,15}\) Cost-effectiveness, however, has been evaluated mostly in large groups of patients with cervical cancer regardless of their primary disease stage. PET-CT in surveillance can be of great importance in patients with locally advanced disease who have a higher risk of local recurrence with the option of curative salvage treatment. A total of 105 patients with locally advanced cervical cancer who underwent primary chemoradiation were observed in an Australian prospective cohort study.\(^{16}\) Single PET-CT was performed after the primary treatment was terminated. The 5-year progression-free survival rate reached 86% and 0% in patients with and without complete metabolic response, respectively. Even more important, of 16 patients who underwent salvage therapy, the disease was detected in 12 of them with a surveillance PET scan.

The key step before any PE for curative intent is performed is the exclusion of metastatic lesions in distant locations. The gold standard is currently considered to be PET-CT, which has a higher sensitivity than CT.\(^{17,18}\) Experiences with whole-body diffusion-weighted magnetic resonance imaging (MRI) and PET-MRI show comparable or even higher accuracy and better diagnostic confidence with these modalities than with PET-CT; the results are, however, based on small cohorts.\(^{19-21}\) Given the high demands of PE for the patient, and also the costs of the procedure and perioperative management, the most accurate available method should always be used to exclude a distant tumor spread before the operation, such as PET-CT or PET-MRI.

A distinct issue is the assessment of the local tumor extent in the pelvis, such as the infiltration of adjacent organs and key structures in the pelvis. Precise knowledge of local tumor spread is crucial for determining the extent of the procedure and providing adequate patient counseling before the operation and also for guiding the surgeon during the procedure. Pictures from preoperative imaging studies (ultrasound, MRI, CT, PET-CT) from two patients with locally advanced cervical cancer are shown in Fig. 15.4.
MRI is considered the gold standard, due to its excellent soft tissue contrast. In a cohort of 50 patients from Memorial Sloan Kettering Cancer Center (MSKCC), preoperative MRI was highly accurate not only in the assessment of bladder and rectum invasion (sensitivity, 81%–87%; specificity, 93%–97%), but also in the identification of pelvic side wall invasion (sensitivity, 88%; specificity, 97%).

It is important to note, though, that its sensitivity is not 100%, and the extent of surgery could be altered according to any intraoperative findings. Imaging reliability may be lower after radiotherapy or chemotherapy, in particular when the interval from the previous treatment is short. Unfortunately, disease extent tends to be larger than predicted with preoperative imaging.

The use of quantitative metrics of pretreatment imaging offers a new, potentially useful tool. Metabolic tumor volume and total

---

**FIG. 15.4 Preoperative Imaging Studies from Two Patients with Locally Advanced Cervical Cancer.** Case 1: (A1) Sagittal plane of magnetic resonance imaging (MRI) and (A2) ultrasound scan (US) showing cervical cancer infiltrating the bladder and sigmoid colon. (B1) Transversal plane of contrast-enhanced computed tomography (ceCT) and (B2) US showing deep bladder invasion by cervical cancer. Deeper infiltration was found on the left side of the bladder. Ureteral stents are inserted bilaterally. (C1) Transversal plane of ceCT and (C2) US showing deep cervical cancer infiltration of the rectum from the left sacrouterine ligament with bilateral pelvic side wall infiltration. Case 2: (A1) Transversal plane of fluorodeoxyglucose-positron emission tomography integrated with computed tomography scan (FDG-PET/CT) demonstrating bladder and sigmoid colon infiltration by large cervical cancer; infiltrated lymph nodes (LNs) are in the left obturator fossa. (A2) Sagittal plane of US showing in large detail the depth of bladder invasion including submucosa, yet the bladder mucosa stays intact. Cranio-caudal (1) and anteroposterior (2) diameters of infiltrated ventral parametria are shown. (B1) Transversal plane of CT retrieved from FDG-PET/CT demonstrating bladder and sigmoid colon infiltration by large cervical cancer; infiltrated lymph nodes (LNs) are in the left obturator fossa. (B2) Sagittal plane of US showing retraction of sigmoid colon loops toward the infiltrated dorsal parametria. (C1) Transversal plane of CT retrieved from FDG-PET/CT showing hydronephrosis of second grade in the right kidney. (C2) Sagittal plane of US scan demonstrating right kidney hydronephrosis; measurements of dilated renal calyx (1) and pelvis (2) are shown.
lesion glycolysis of FDG (18F-fluorodeoxyglucose) uptake derived from PET scans and the mean apparent diffusion coefficient derived from diffusion-weighted MRI were shown to be associated with the prognosis.\(^23,24\) Functional metrics could be used in the future to triage patients with higher risk of a recurrence so that they are surveilled more intensely after primary treatment. It might also contribute to the decisions about PE execution as a prognostic marker.

**Prognostic Factors and Contraindications**

**Prognostic Factors**

The 5-year cumulative survival rate after PE varies greatly in the literature, from as low as 20% to up to 70% (Table 15.1). Such a span cannot be caused by a volatile quality of surgical performance. Even though the ability to reach free margins can be higher in institutions in which surgeons have expertise with combined procedures, these cases always represent a limited part of a cohort. The decisive factor for the oncologic outcome in the whole cohort are the selection criteria. They correspond to the main prognostic parameters, such as positive pelvic and paraaortic LNs, lateral pelvic attachment, histologic types, the disease-free interval from the primary treatment, or the presence of symptoms at the time of diagnosis. The overall outcome can, however, be influenced by other criteria, such as age, obesity, or performance status. Even though they are not typically listed as prognostic factors, they can significantly increase morbidity and also diminish the ability to reach R0.

**TABLE 15.1** Morbidity, Mortality, and Survival of Patients With Pelvic Exenteration for Gynecologic Pelvic Malignancies in Series Published Before and After Year 2000 (N ≥ 50)

<table>
<thead>
<tr>
<th>Year (Series Published Before Year 2000 (N ≥ 50))</th>
<th>No. of Patients</th>
<th>Morbidity (%)</th>
<th>Mortality (%)</th>
<th>5-Year Survival (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiselow et al.(^43)</td>
<td>1967</td>
<td>207</td>
<td>42</td>
<td>8</td>
</tr>
<tr>
<td>Symmonds et al.(^44)</td>
<td>1975</td>
<td>198</td>
<td>78</td>
<td>8</td>
</tr>
<tr>
<td>Rutledge et al.(^45)</td>
<td>1977</td>
<td>296</td>
<td>NA</td>
<td>14</td>
</tr>
<tr>
<td>Averette et al.(^46)</td>
<td>1984</td>
<td>92</td>
<td>NA</td>
<td>10 (29)(^a)</td>
</tr>
<tr>
<td>Jakowatz et al.(^47)</td>
<td>1985</td>
<td>104</td>
<td>49</td>
<td>3</td>
</tr>
<tr>
<td>Kraybill et al.(^48)</td>
<td>1988</td>
<td>99</td>
<td>71</td>
<td>14</td>
</tr>
<tr>
<td>Anthropoulos et al.(^49)</td>
<td>1989</td>
<td>20</td>
<td>74</td>
<td>5</td>
</tr>
<tr>
<td>Hatch et al.(^50)</td>
<td>1990</td>
<td>31</td>
<td>32</td>
<td>0</td>
</tr>
<tr>
<td>Lawhead et al.(^51)</td>
<td>1989</td>
<td>65</td>
<td>NA</td>
<td>9</td>
</tr>
<tr>
<td>Shingleton et al.(^30)</td>
<td>1989</td>
<td>143</td>
<td>NA</td>
<td>6</td>
</tr>
<tr>
<td>Soper et al.(^52)</td>
<td>1989</td>
<td>69</td>
<td>84</td>
<td>7</td>
</tr>
<tr>
<td>Morley et al.(^6)</td>
<td>1989</td>
<td>100</td>
<td>49</td>
<td>2</td>
</tr>
<tr>
<td>Ketcham et al.(^53)</td>
<td>1970</td>
<td>162</td>
<td>NA</td>
<td>17</td>
</tr>
<tr>
<td>Hafner et al.(^54)</td>
<td>1992</td>
<td>75</td>
<td>75</td>
<td>5</td>
</tr>
<tr>
<td>Lopez et al.(^55)</td>
<td>1993</td>
<td>248</td>
<td>60</td>
<td>12</td>
</tr>
</tbody>
</table>

**Series Published After Year 2000 (N ≥ 50)**

<table>
<thead>
<tr>
<th>Year (Series Published After Year 2000 (N ≥ 50))</th>
<th>No. of Patients</th>
<th>Morbidity (%)</th>
<th>Mortality (%)</th>
<th>5-Year Survival (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berek et al.(^56)</td>
<td>2005</td>
<td>75</td>
<td>86(^a)</td>
<td>0</td>
</tr>
<tr>
<td>Yoo et al.(^57)</td>
<td>2012</td>
<td>61</td>
<td>44</td>
<td>0</td>
</tr>
<tr>
<td>Nguyen et al.(^48)</td>
<td>2005</td>
<td>76</td>
<td>28</td>
<td>0</td>
</tr>
<tr>
<td>Goldberg et al.(^8)</td>
<td>2006</td>
<td>103</td>
<td>71(^a)</td>
<td>1</td>
</tr>
<tr>
<td>Marnitz et al.(^28)</td>
<td>2006</td>
<td>55</td>
<td>57</td>
<td>6</td>
</tr>
<tr>
<td>Maggioni et al.(^7)</td>
<td>2009</td>
<td>106</td>
<td>66</td>
<td>0</td>
</tr>
<tr>
<td>Fotopoulou et al.(^58a)</td>
<td>2010</td>
<td>47</td>
<td>70</td>
<td>9</td>
</tr>
<tr>
<td>De Wever(^59,60)</td>
<td>2011</td>
<td>106</td>
<td>70</td>
<td>0</td>
</tr>
<tr>
<td>Baiocchi et al.(^9)</td>
<td>2012</td>
<td>107</td>
<td>53</td>
<td>0</td>
</tr>
<tr>
<td>Schmidt et al.(^11)</td>
<td>2012</td>
<td>282</td>
<td>51</td>
<td>5</td>
</tr>
<tr>
<td>Chiantera et al.(^10)</td>
<td>2014</td>
<td>167</td>
<td>35</td>
<td>0</td>
</tr>
<tr>
<td>Fleisch et al.(^61)</td>
<td>2007</td>
<td>203</td>
<td>41</td>
<td>1</td>
</tr>
<tr>
<td>Urh et al.(^62)</td>
<td>2013</td>
<td>133</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Jurado et al.(^25)</td>
<td>2010</td>
<td>48</td>
<td>71</td>
<td>0</td>
</tr>
</tbody>
</table>

\(^a\)Only inflammatory.  
\(^b\)R0 + lymph-node negative.  
\(^c\)Ten-year overall survival.  
NA, Not applicable.
The decision to perform PE is always a complex and complicated process, one that must be made individually after careful consideration of all potential prognostic parameters. Patient preferences must always play a significant role in the entire process. More stringent selection criteria improve the institution’s results; at the same time, they inevitably exclude patients who would potentially benefit from PE. If the institution does not offer PE to patients with pelvic LN involvement, with pelvic side wall fixation, with the presence of symptoms corresponding to pelvic large nerve compression, or with a short interval from primary treatment, the proportion of cured patients will be higher. At the same time, a chance is then taken away from the 20% to 30% of patients who can be cured by an adequately performed salvage procedure.

**Surgical Margins**

In planning and carrying out a procedure, it is important to bear in mind that the main prognostic factor for PE is achieving free surgical margins.\(^7\,10,25,26\) The long-term survival of patients with remaining tumor residuum after PE reaches less than 10% irrespective of further adjuvant treatment and other prognostic factors.\(^9\) If there is any doubt about tumor involvement during the operation, a biopsy specimen should always be taken from the suspicious location and sent for intraoperative histologic review. To sum up, the goal of every procedure with a curative intent must be complete tumor removal.

**Histologic Type**

The importance of histologic type differs according to tumor type. In cervical cancer, the data in the literature are inconsistent, showing the same or worse survival rates in adenocarcinoma in comparison with squamous cancer. In the largest published cohort (282 patients) with cervical cancer, the 5-year survival rate was 31% in patients with adenocarcinoma, but 41% in those with squamous cancers.\(^1\) It is not surprising that in uterine cancer a much better prognosis is associated with endometrioid histotype, whereas in serous cancer, mixed cancer, or carcinosarcoma the 5-year survival oscillates below 20%.\(^7,27\)

**Lymph Node Status**

LN involvement is not a rare finding in patients referred for PE. The risk oscillates between 10% and 30%, depending on tumor types, previous treatment, and the method used in the preoperative workup. In considering the benefits of the procedure and counseling patients, the right assessment of prognostic significance is of great importance. In mixed cohorts of gynecologic tumors, a positive LN is mostly a considerably negative prognostic factor.\(^7,9,10\) These data are, however, biased to a certain extent, because a systematic lymphadenectomy is not typically a routine part of PE, so LNs are removed selectively only if they are enlarged and patients with a recurrent tumor have often undergone a lymphadenectomy already. In addition, the localization of positive LNs is not distinguished in many papers. The authors from two institutions in Germany and Switzerland published their results on PE in a large group of women with primary (25%) or recurrent (75%) cervical cancer (N = 282).\(^1\)

In 21% of cases, patients had positive LNs only in the pelvis and 28% in the paraaortic region. The involvement of pelvic LNs did not decrease the 5-year survival compared with the group without positive LNs (45% vs. 50%), whereas the positivity of paraaortic LNs was associated with a dismal 5-year survival (17%). Available data show that pelvic LN involvement can worsen the prognosis, but it should not be taken as an absolute contraindication; positive paraaortic LNs must be considered to be distant metastases associated with a very low probability of long-term survival. Limited data are available regarding the prognostic significance of involved inguinal LNs in patients undergoing PE, even though it is not a rare finding.

**Time to Recurrence**

In the majority of tumors, the interval from primary treatment to recurrence reflects the tumor’s biological behavior. Although some smaller studies did not find prognostic significance of a progression-free interval from the primary treatment in patients after PE for a recurrent tumor,\(^28\) the majority of authors reported a substantially better prognosis with a long interval from the initial treatment.\(^5,29,30\) Marnitz reported 5-year survival rates in patients with a recurrence up to 2 years, between 2 and 5 years, and more than 5 years after the initial treatment of 17%, 28%, and 83%, respectively.\(^26\) It should be emphasized that patients with a very early tumor progression, up to 1 year after the primary treatment, represent an extremely unfavorable prognostic group for PE procedures.

**Other Factors**

For a variety of other factors, a significant influence on patient prognosis has not been proven, or the findings are inconsistent. In some studies a better survival rate was demonstrated in patients with endometrial cancer\(^7\) in comparison to cervical cancer. The comparison is, however, limited by a much lower representation of patients with endometrial cancer. In large studies, 5-year survival in both endometrial and cervical cancer ranges from 35% to 50%.\(^7,27,29\) Other factors that have not been evaluated in the majority of studies are the presence, character, and duration of symptoms. The involvement of large pelvic vessels or nerves is an indirect sign of local progression of a tumor. Most studies did not find any prognostic significance for patient age or type of PE performed (anterior, posterior, total).

**Contraindications**

The assessment of absolute contraindications to PE has changed over time. Some absolute contraindications have become less stringent. Given the fact that this operation does not have an alternative in most cases, it is necessary to evaluate the situation for each patient individually. Particularly, the surgical limits for locally advanced pelvic tumors have noticeably changed. Many tumors that in the past were considered unresectable do have a possible solution, thanks to new technologies and new surgical techniques that increase the chances of reaching free margins.

If the tumor is attached to lateral pelvic muscles and the internal iliac vessels are invaded, a laterally extended resection can be offered. Surgical solutions are also available for patients with focal pelvic bone involvement, infiltration of external iliac vessels, or large pelvic nerves. Each of these complex resections is associated with severe, often permanent, morbidity, however. It is also important to take into account that a larger local extent of tumor decreases chances for a curative outcome. However, there are patients, in particular those with slowly growing tumors, without any signs of a distant spread even if the pelvic progression is extensive; the technical solution of local resection offers the only chance of survival for such patients. In these patients an individual approach is mandatory, including assessment of all further prognostic factors, the patient’s overall condition (age, comorbidities, performance status), other
Pelvic Exenteration for Gynecologic Cancers

limitations of the surgical approach (body mass index, previous surgeries, previous radiotherapy), and also “soft” factors, such as the patient’s motivation, her ability to understand the extent of the procedure and its consequences, and the expected adherence to postoperative care. Even with an eligible patient who has a surgical solution available to her, the patient’s consent is the decisive factor.

The only remaining absolute contraindication is the presence of distant unresectable metastases. Even when these distant lesions can be removed, the prognosis of the patient with a locally advanced tumor and distant metastasis is very poor, and the long-term survival rate is less than 10%.31 In cervical cancer, paraaortic LN involvement must be considered a distant metastasis.

**Surgical Technique**

Unlike other surgical procedures in gynecologic oncology, such as pelvic lymphadenectomy or radical hysterectomy, in which each step can be standardized in great detail, PE has an array of alternatives at each step and must always be tailored to the specific case. In addition to tumor localization and the involvement of pelvic organs and structures, one also has to take into consideration previous treatment, including pelvic radiation. Given the great variability, the PE technique is described in this chapter schematically. Each surgeon must be prepared to adjust the respective steps according to intraoperative findings.

**Development of Pelvic Spaces**

Just as in other pelvic procedures, the key step is a dissection of the standard pelvic planes. The paravesical space is opened laterally, as is the lateral pararectal space between the dorsal parametrium and the internal iliac vessels. In the case of severe postradiation fibrosis, the safe landmark is the course of the pelvic iliac vessels, which are identified below their bifurcation and followed to the pelvis. The Retzius space is opened ventrally (total or anterior PE), or the bladder is dissected completely from the cervix and proximal vagina (posterior PE). Dorsally, the presacral space is usually developed after the colon is divided and mobilized (posterior or total PE) or the rectovaginal space is opened, and the rectum is dissected from the vagina and dorsal parametria.

**Ureteral Dissection**

The technique of ureteral mobilization is also adjusted according to the type and extent of PE. In a total PE, the ureter is interrupted above its involvement into the tumor, usually before its entrance into the lateral parametria. In patients who have undergone previous radiotherapy, a compromise is reached between the resection of heavily irradiated portions and preservation of sufficient length for an intended reconstruction. In posterior PE, the disease extent usually enables keeping the ureter intact after it has been completely freed from the parametria; eventually, a resection of its distal part is necessary with a consecutive reconstruction by a direct reimplantation into the bladder, end-to-end anastomosis, ureteroureteral anastomosis, or replacement with excluded small bowel. In a heavily irradiated pelvis, the preoperative insertion of ureteral stents may facilitate identification and safer dissection.

**Ligament (Parametria) Detachment**

In the next step, the specimen in the pelvis is mobilized by the resection of the parametria at the intended plane.

1. Lateral dissection. Lateral parametria are interrupted laterally at the attachment to the lateral pelvic side wall at the medial aspect of the internal iliac vein completely up to the sacral bone. Deep parametral dissection of the lateral parametria is a risky step, particularly in patients who have undergone previous irradiation. When the medial wall of the internal iliac vein is injured, massive bleeding might be difficult to control; this region can be difficult to access, mainly in obese patients or in the presence of bulky pelvic tumors, when there is not enough space for vessel repair. The best prevention is to identify the medial wall of the internal iliac vein at the point of iliac bifurcation and then follow its medial wall caudally.
2. Ventral dissection. Ventral parametria (bladder pillars) are interrupted either at the posterior bladder wall (posterior PE) or at the attachment to the inferior aspect of the pubic bones (total or anterior PE).
3. Dorsal dissection. Dorsal parametria (uterosacral ligaments) are interrupted either at the level of the rectum (anterior PE) or on the lateral aspects of the presacral space at the sacral bone (total or posterior PE).

**Endopelvic Fascia and Levator Ani Muscle Resection**

After complete detachment of the ventral, lateral, and dorsal parametria, the pelvic specimen is mobilized centrally in the pelvis all the way to the endopelvic fascia, which covers the pelvic floor (pelvic diaphragm). If the tumor is attached to or has infiltrated the pelvic floor, its resection becomes part of infralevatoric PE (types II and III). Meticulous dissection and bleeding control are recommended because the space between the fascia and levator ani muscle is richly vascularized.

**Vaginectomy**

A complete vaginectomy is generally described as part of infralevatoric exenteration. In a typical location of a recurrent cervical cancer, a proximal part of the vagina is usually infiltrated, and the distal part can be preserved. A proximal vaginectomy can be performed adequately from the abdominal approach without the need to carry out a perineal part of the procedure. The preservation of a distal part of the vagina and the urogenital diaphragm not only is significant for the quality of sexual life, but it also decreases the risk of empty pelvis syndrome. If the vulva, distal part of the vagina, or rectovaginal septum is involved, distal colpectomy, vulvectomy, or both are performed from a perineal approach.

**Perineal Resection**

The extent of the perineal operation should always be individualized with respect to the disease extent. If the vulva is not infiltrated, an external incision line is made at the level of the introitus, with preservation of the external genitalia.

The sequence of the abdominal and perineal parts of the surgery is usually determined by the location of the dominant tumor infiltration. In tumors localized above the pelvic diaphragm or attached to the pelvic floor, PE is initiated abdominally, because the definite extent of the resection is determined according to the intraoperative finding. In vulvar or vaginal cancer, the operation is typically initiated from the perineal approach. In tumors with a high risk of bleeding, in particular when the pelvic floor is massively infiltrated or the tumor is fixed to the side wall, a specimen mobilization is recommended from both the abdominal and perineal approaches.
in the first step, so the riskiest dissection is performed as the final step, and, in case of massive bleeding, a comfortable access for hemostasis can be obtained more quickly after the entire specimen has been removed. The exenteration is followed by a reconstruction procedure, which is described in more detail in Chapter 20.

Oncologic Outcomes

The main reason that such extensive procedures, which are associated with high morbidity and impairment of quality of life in the majority of patients, still belong to the portfolio of standard procedures in the management of gynecologic pelvic tumors is that there is a relatively high chance of long-term patient survival. Particularly in patients with tumor recurrence who underwent pelvic radiotherapy as a primary treatment, there is in most cases no other alternative available that has a curative potential. In addition, these tumors respond poorly to palliative systemic treatment.

Table 15.1 summarizes studies with more than 50 patients who underwent PE for gynecologic malignancy that were published before and after 2000. It is obvious from the summary that in only a few decades there was a significant reduction of mortality achieved. A distinct improvement in the 5-year survival rate cannot, however, be observed. Obviously, even an extremely extensive procedure cannot improve the prognosis in patients with occult distant metastases.

It is apparent from Table 15.1 that there are large differences in survival rates among individual publications. The comparison is biased by a number of factors, such as proportion of tumor types, proportion of primary versus recurrent tumors, previous radiotherapy, intraoperative and postoperative radiotherapy, or length of the follow-up period. The oncologic outcome is mostly affected by the selection criteria used in the decision to perform PE. In large mixed cohorts of patients with a recurrence of vulvar, endometrial, and cervical cancer who underwent surgical procedures with curative intent, the long-term survival rates oscillate around 50% to 60% (see Table 15.1). The largest group of patients with a single type of cancer included 282 patients with primary (70) or recurrent (212) cervical cancer.

The 5-year survival rate reached 41% in the whole group and 64% in patients with R0.

Combined Treatment

Intraoperative Radiotherapy

Intraoperative radiotherapy (IORT) has been developed to increase local control after the resection of pelvic malignancies, especially in the treatment of recurrent tumors. IORT is delivered at the time of the operation after maximum surgical resection.

The assessment of the significance of IORT for local control enhancement is difficult to make. The available data have a number of serious limitations, such as a long period of accrual, mostly small groups of cases, mixed populations of different tumor types, combination of IORT with postoperative radiotherapy or chemotherapy, and an absence of control groups without IORT (Table 15.2).

Vast discrepancies in local control and overall survival reflect different cohorts and criteria for the selection of patients. In the mixed tumor population, it seemed that IORT tends to be more effective in patients with endometrial cancer. Nevertheless, in studies in which the amount of residual disease after the resection was assessed, the oncologic outcome was poor in patients with macroscopic residual disease, notwithstanding the delivery of IORT. No definite conclusion can be made from the available data, but an important message is that IORT does not represent an alternative to an adequate resection. The goal of the surgical procedure should always be to find a technical solution to reach free margins.

Preoperative Chemotherapy

The motivation for use of chemotherapy before PE is twofold: tumor downsizing and elimination of minimal clinically occult disease in distant locations. The experience with neoadjuvant chemotherapy before PE is, however, very limited. In the largest cohort, Italian authors compared the results in patients with recurrent cervical cancer after PE with (n = 31) or without (n = 30) preoperative chemotherapy. In the group of patients who received chemotherapy, there was a significantly larger median tumor size (44 vs. 20 mm), and a higher proportion of patients had lateral pelvic wall invasion (45% vs. 20%). Although the differences in oncologic outcome did not reach statistical significance, there still was an apparent trend toward shorter overall survival (43 vs. 112 months) and disease-free survival (36 vs. 48 months) in the group with chemotherapy and poorer prognostic factors. Furthermore, in 40% of patients, the authors described only stable disease or disease progression while the patients were receiving chemotherapy.

There are no data available currently that show improvement of PE results after previous chemotherapy. It is unlikely that chemotherapy can make inoperable disease resectable, and the ability to tackle occult metastatic disease is difficult to prove. Moreover, especially in patients who have undergone previous radiotherapy, the local distribution of the agent can be notably impaired. Another potential risk is the progression of the disease when PE is postponed, mainly in a substantial group of nonresponders.

Extension of Radiality

One of the most significant improvements in the management of patients with locally advanced or recurrent tumors can be seen in radicality enhancement and extension of indications to patients with involvement of the pelvic side wall. It is important to bear in mind that the main goal of PE with a curative objective is the achievement of a complete resection. If the tumor is not removed completely, the progression after PE is usually very rapid, and the only outcome of the operation is deterioration in the quality of the remaining life.

Even with the increasing quality of imaging methods, the description of the tumor extent in the pelvis is often inaccurate, particularly in patients who have undergone previous radiotherapy, in whom it is difficult to differentiate malignant tissue from postradiation tissue changes. The surgical team should therefore be experienced in procedures that allow expansion beyond the traditional anatomical limits of PE and should be able to adjust the surgical procedure according to the intraoperative findings. Lateral pelvic attachment of the tumor is a risk prognostic factor; so is the involvement of other pelvic structures such as large vessels, large pelvic nerves, or bones. In many of these situations, which were considered absolute contraindications in the past, complete resection can be technically achieved; they are, however, associated with additional specific morbidity. These techniques are useful in addition to classic PE indications in the treatment of slowly growing tumors with low risk of metastatic spread, such as low-grade ovarian tumors.
TABLE 15.2 Overview of Studies on Intraoperative Radiotherapy (IORT) in Patients With Gynecologic Cancer (N > 20)

<table>
<thead>
<tr>
<th>Reference</th>
<th>No. of Patients</th>
<th>Type of Tumor</th>
<th>Primary or Recurrent</th>
<th>IORT Median Dose (Gy)</th>
<th>Exenteration (%)</th>
<th>Preoperative or Postoperative RT (%)</th>
<th>LRR</th>
<th>OS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gérard et al.</td>
<td>63</td>
<td>Uterine</td>
<td>Mixed</td>
<td>—</td>
<td>100</td>
<td>100</td>
<td>4/20</td>
<td>18 mo</td>
</tr>
<tr>
<td>Stelzer et al.</td>
<td>22</td>
<td>Cervix</td>
<td>Recurrent</td>
<td>22</td>
<td>32</td>
<td>27</td>
<td>10/22</td>
<td>43%</td>
</tr>
<tr>
<td>Mahé et al.</td>
<td>70</td>
<td>Cervix</td>
<td>Recurrent</td>
<td>19</td>
<td>100</td>
<td>43</td>
<td>50/67</td>
<td>8%</td>
</tr>
<tr>
<td>Martinez-Monge et al.</td>
<td>31</td>
<td>Cervix</td>
<td>Primary</td>
<td>12</td>
<td>16</td>
<td>65</td>
<td>6/31</td>
<td>58%</td>
</tr>
<tr>
<td></td>
<td>36</td>
<td>Cervix</td>
<td>Recurrent</td>
<td>15</td>
<td>75</td>
<td>14</td>
<td>18/36</td>
<td>14%</td>
</tr>
<tr>
<td>Gemignani et al.</td>
<td>17</td>
<td>Cervix</td>
<td>Recurrent</td>
<td>14</td>
<td>59</td>
<td>12</td>
<td>4/17</td>
<td>54%</td>
</tr>
<tr>
<td>Tran et al.</td>
<td>17</td>
<td>Mixed</td>
<td>Recurrent</td>
<td>12</td>
<td>18</td>
<td>53</td>
<td>11/17</td>
<td>47%</td>
</tr>
<tr>
<td>Foley et al.</td>
<td>32</td>
<td>Mixed</td>
<td>Recurrent</td>
<td>14</td>
<td>NA</td>
<td>NA</td>
<td>9/32</td>
<td>70%</td>
</tr>
<tr>
<td>Arians et al.</td>
<td>36</td>
<td>Mixed</td>
<td>Recurrent</td>
<td>15</td>
<td>NA</td>
<td>92</td>
<td>28/36</td>
<td>22%</td>
</tr>
<tr>
<td>Dowdy et al.</td>
<td>25</td>
<td>Endometrium</td>
<td>Recurrent</td>
<td>15</td>
<td>36</td>
<td>84</td>
<td>6/25</td>
<td>47%</td>
</tr>
<tr>
<td>Backes et al.</td>
<td>32</td>
<td>Mixed</td>
<td>Recurrent</td>
<td>18</td>
<td>100</td>
<td>19</td>
<td>14/32</td>
<td>NA</td>
</tr>
<tr>
<td>Barney et al.</td>
<td>13</td>
<td>Cervix</td>
<td>Primary</td>
<td>13</td>
<td>56</td>
<td>71</td>
<td>4/13</td>
<td>29%</td>
</tr>
<tr>
<td></td>
<td>73</td>
<td>Cervix</td>
<td>Recurrent</td>
<td>18</td>
<td></td>
<td></td>
<td>33/71</td>
<td>25%</td>
</tr>
</tbody>
</table>

LRR, Local recurrence rate; NA, not available; OS, overall survival; RT, radiotherapy.

TABLE 15.3 Structures Potentially Resectable in Lateral Pelvic Side Wall Excision

<table>
<thead>
<tr>
<th>Cranial Segment</th>
<th>Ventral Segment</th>
<th>Dorsal Segment</th>
<th>Caudal Segment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medial part of the psoas and iliacus muscle</td>
<td>Obturator vessels</td>
<td>Obturator nerve</td>
<td>Obturator fascia and muscle</td>
</tr>
</tbody>
</table>

Lateral Pelvic Side Wall Excision

The term laterally extended endopelvic resection (LEER) was introduced by Höckel and is mostly used in gynecologic oncology; in the surgical literature the term extended lateral pelvic side wall excision (ELSE) is preferred. Höckel published a unique study of 91 patients with primary locally advanced or recurrent cervical or vaginal cancer in whom LEER was performed. In 77% of them the tumor was fixed to the pelvic side wall. The oncologic outcome was not different in primary versus recurrent tumors and not even in central versus laterally fixed tumors. The main prognostic factor was LN involvement. Local control of 92% was surprisingly high; even more astonishing was the 5-year survival rate of 61%. Since then, many other authors have referred to their experience with laterally extended resections in smaller cohorts.

These resections are anatomically not exactly determined; in general, they include the region defined cranially by the external iliac vessels, medially by the internal iliac vessels, dorsally by the sacral bone, and laterally by the pelvic bones, the lumbosacral plexus, and the femoral nerve. Fig. 15.4 with Cases 1 and 2 illustrates schematically the respective segments of the pelvic side wall, and Table 15.3 presents structures that are potentially resectable as a component of lateral pelvic side wall excision.

Resection of Large Vessels, Nerves, and Bones

In the gynecologic literature, the anatomic limit for PE is often described as the involvement of pelvic bones, external iliac vessels, or the lumbosacral plexus. These limitations are, however, relative. Technically, it is possible to overcome these situations by increasing the extent of the resection. Each of these procedures is associated with additional specific serious morbidity, which is, in most cases, permanent. Each patient referred for PE must be evaluated individually. As an example, a laterally fixed tumor with sciatic nerve infiltration will require an extensive procedure with severe consequences for lower limb mobility. The radical resection is nevertheless technically feasible, and it is ethically difficult not to offer the treatment to a young woman in good overall condition without evidence of distant tumor...
spread. Given the technical complexity and low frequency of these procedures, the data in the literature are scarce.

**Resection of External Iliac or Common Iliac Vessels**

Given the topography of the external iliac vessels, the tumor that grows from the obturator fossa typically infiltrates first the vein that runs below the external iliac artery. External or common iliac veins are therefore involved more often than corresponding arteries. If the tumor is firmly fixed to or infiltrating the wall of one of these large veins, according to both our center's experience and the limited data in the literature, their ligation and resection are feasible without a need for reconstruction. Our center's experience includes six cases of external and/or common iliac vein resection. The consequence of the vein ligation was a severe lower limb edema that manifested immediately after the surgery but gradually resolved over a few days. Only one case was complicated by ischemia of a lower extremity, but that was a result of thrombosis of the external iliac artery.

Much more demanding is a situation in which the external iliac artery is involved. Case reports have been described in the literature of external iliac artery ligation without limb loss.\(^{36,37}\) A ligation of the artery is, however, associated with the risk of a critical hypoperfusion of a lower extremity. As mentioned earlier, in our center's own series there was a case involving a resection of the external and common iliac veins, tumor dissection from the external iliac artery, and thrombosis of the artery in the early postoperative period. Severe acute lower limb ischemia necessitated performance of femorofemoral arterial bypass and emergent fasciotomy owing to an acute compartment syndrome.

Reconstruction should always be performed if the external iliac artery must be resected. A method of choice is a femorofemoral bypass, which can be performed during the same procedure, or even better as a preparatory procedure with PE following as the second step.

The preoperative assessment of vessel involvement is often inaccurate. In our center's experience, neither MRI nor CT angiography allows reliable differentiation of whether the compressed vessel can be dissected from the tumor or the vessel wall is already infiltrated and will have to be resected. In these cases the decision is based on intraoperative findings; the surgical team must be prepared for the worst-case scenario, and the patient should be counseled accordingly.

Only small cohorts of patients after a resection of common or external iliac vessels have been described in the literature. Researchers from MSKCC published data on five patients.\(^38\) Both cases of a resection of external or common iliac veins were handled by means of vein ligation without reconstruction. In one case, the resection of the external iliac artery was followed by a femorofemoral bypass. The findings from a much larger cohort of patients with major vascular resection were published by Solomon and Austin from the University of Sydney.\(^39\) In 16 cases, common or external iliac vessels were resected. Unfortunately, more details are lacking in the report, so it is unclear if the procedure involved veins or arteries or whether any type of reconstruction was executed.

**Large Pelvic Nerve Resection**

In the past, extensive pelvic nerve infiltration, like bone infiltration, was considered to be an absolute contraindication to PE. Its diagnosis is usually straightforward because nerve compression is associated with significant symptoms, such as pain or numbness. According to the localization of the symptoms, which nerve is affected and in which location can be determined. In the majority of cases, nerve involvement is a sign of very advanced disease.

It is obvious that the nerve resection per se is not technically demanding, but it usually has serious consequences for the patient that are specific to the respective nerve. If the resection of the large nerve comes into consideration, the potential morbidity must be thoroughly discussed with the patient.

The authors from MSKCC presented a group of 10 patients with resection of a major pelvic nerve, including the lumbosacral nerve root (five patients), obturator nerve (three patients), and femoral nerve (two patients).\(^36\) Unfortunately, the article does not specify postoperative morbidity associated with these operations. In our center's own cohort, a resection of major pelvic nerves was performed in 11 patients, including a partial resection of a femoral nerve (two patients), complete resection of an obturator nerve (six patients), complete resection of an ischial nerve (one patient), and partial resection of lumbosacral plexus (four patients). The consequences for motor skills are individual, in particular after partial resections. After a longer interval from the procedure and adequate rehabilitation, the functional loss is often not substantial. Even after a complete resection of the obturator nerve, the patient can reach nearly full motor recovery. A larger or complete lesion of the femoral or ischial nerve always has severe consequences that correspond to the innervation of particular muscle groups (Table 15.4). Localized sensation loss is also typical for each nerve lesion (Fig. 15.5).

**Composite Exenteration**

The term composite pelvic exenteration is used for a procedure in which the exenteration is combined with a resection of the pelvic bone. This comprehensive resection is not an invention of the past decade; as early as 1969, Brun Schwig and Barber described 28 patients who underwent composite PE within 10 years for colon, vulvar, vaginal, and cervical cancer.\(^2\) Of 19 patients who underwent operation for a gynecologic tumor, 10 of them survived for more than 12 months.

Reports of more experiences with pelvic bone resection for primary or recurrent treatment of rectal cancer are now available. In the majority of patients, some degree of sacrectomy is performed. A 5-year disease-free survival rate oscillates above 30% in large cohorts.\(^40,41\)

In gynecologic tumors, a fixation of the tumor to the bone or even bone infiltration was considered to be a contraindication to PE. Undoubtedly, just as in patients with large-vessel infiltration, bone involvement is often a sign of disease that is too advanced for surgical treatment. In individual patients, however, bone resection can enable complete resection if distant tumor spread is not present.

The localization of pelvic bone infiltration in gynecologic tumors is different from that in rectal cancer (Fig. 15.6). Moreover, in the majority of patients in whom surgical resection is considered, only a small portion of bone is involved. Complete tumor removal does not require a large resection in the range of inner hemipelvectomies, such as in soft tissue sarcomas.

Locally advanced vulvar or vaginal cancer typically infiltrates the inferior pubic ramus and the pertaining part of the ramus of the ischial bone. The resection of this part of the bone is not technically difficult. It is performed with the Gigli saw and does not compromise the stability of the pelvic girdle; therefore it does not necessitate reconstruction.
In patients with cervical or endometrial cancer, the affected part of the bone is frequently the iliac fossa, the region of the arcuate line of the iliac bone, the superior pubic ramus, the ischial spine, and the pertaining part of the ischial body. The resection of these parts of bones is more demanding and usually requires a combination with LEER and hence with the resection of lateral pelvic muscles. To achieve an adequate radicality, it is sufficient in most patients to resect the periosteum and the inner layer of the compact bone. The stability of the pelvis is not jeopardized even in these cases, so a consecutive reconstruction is not required. The challenge is a potentially higher blood loss from the richly vascularized spongy bone between the two layers of compact bone where the resection is conducted.

Very limited data have been published in the literature about a composite procedure in the treatment of gynecologic tumors since the time of Brunschwig. A cohort of 34 patients from two institutions in the United States and Mexico included six patients with cervical cancer and three patients with vaginal cancer. In all of them, a resection of the ischium and pubic bone was performed. Five-year disease-specific survival reached 52% in the whole group; in the subgroup of gynecologic tumors, three of nine patients were without evidence of the disease after the median follow-up period of 37 months. It is important to emphasize that six of nine patients survived for more than 2 years. A review article from MSKCC on “out-of-the-box”

<table>
<thead>
<tr>
<th>Nerve</th>
<th>Sensory</th>
<th>Motor</th>
<th>Functional Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obturator</td>
<td>Medial thigh</td>
<td>Medial thigh muscles (adductors)</td>
<td>Weak adduction of the thigh</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Numbness and loss of sensation of the inner thigh</td>
</tr>
<tr>
<td>Femoral</td>
<td>Anterior thigh</td>
<td>Anterior thigh muscles (quadriiceps)</td>
<td>Weakness or loss of knee extension</td>
</tr>
<tr>
<td></td>
<td>Medial and posterior leg (saphenous nerve)</td>
<td></td>
<td>Loss of sensation over the anterior thigh</td>
</tr>
<tr>
<td>Sciatic</td>
<td>Posterior and lateral leg</td>
<td>Posterior thigh muscles (hamstrings)</td>
<td>Weakness or loss of knee flexion and loss of ankle and foot movements</td>
</tr>
<tr>
<td></td>
<td>Foot</td>
<td>Posterior and lateral leg muscles (hamstrings)</td>
<td>Inversion and plantar flexion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Foot muscles</td>
<td>Loss of sensation over the anterior and lateral leg and the entire foot</td>
</tr>
<tr>
<td>Pudendal</td>
<td>External genitalia</td>
<td>Pelvic floor muscles and urogenital diaphragm muscles</td>
<td>Loss of sensation over the external genitalia</td>
</tr>
<tr>
<td></td>
<td></td>
<td>External urethral and external anal sphincter</td>
<td>Fecal incontinence</td>
</tr>
</tbody>
</table>

**FIG. 15.5** Sensory innervation of the lower limb.

**FIG. 15.6** Pelvic bones typically infiltrated by gynecologic tumors.
pelvic surgery included eight cases of bone resection. Unfortunately no details were given as to which parts of the pelvic bones were resected or what the results were in this subgroup of women. In the whole group of 22 patients with a resected muscle, nerve, bone, or large vessel, 5-year overall survival reached 34%; in 17 patients with free margins, it reached 48%.

Our center's own experience includes six cases of bone resection combined with PE, all performed within the past 4 years, which entailed the following procedures: resection of inferior pubic ramus; partial resection of pubic bone; resection of inferior pubic ramus together with the ramus of ischium; partial resection of the body of ischial bone; and extensive resection of the inner layer of the compact bone of the iliac fossa, iliac bone, and body of the ischial bone. Three patients are currently without evidence of disease, one patient died of local and distant disease progression, and two patients underwent operation a short time ago.

Counseling

In considering PE, the patient's informed consent is of special importance, given the extreme nature of the operation, the high morbidity rate, and the potentially severe consequences for the patient's quality of life.

Consent for the procedure must be given based on complete and objective information that is explained in a way that is comprehensible to the individual patient. Because of the large amount and complexity of information associated with the decision, all facts cannot usually be conveyed in one session. The decision-making process usually requires several appointments and the involvement of an interdisciplinary team. It is crucial, more so than with other procedures, to invite family members who can help the patient make a final decision and who will often be involved in her recovery.

Patient counseling is complicated by the fact that the extent of the procedure is often determined based on intraoperative findings. Particularly in tumors fixed to the pelvic side wall and in patients with a short interval after previous radiotherapy or chemotherapy, the imaging methods are less reliable, and the patient must be informed about a possible intraoperative enhancement of the procedure. Informed consent must therefore include more potential alternatives. Some authors recommend using a staging laparoscopy as the first step, often in combination with surgical staging of LNs. Laparoscopic exploration can exclude possible peritoneal spread, although it often does not allow an accurate assessment of its local extent in the pelvis.

The following topics must be discussed with the patient when PE is being considered: (1) extent of the disease, (2) extent of the planned operation, (3) presumed prognosis after PE, (4) planned reconstructive procedures, (5) expected morbidity, (6) potential long-term consequences for the patient's quality of life, and (7) alternative treatment modalities and their prognosis.

An important part of the complex information is also a prognosis if PE is not performed. The expected survival can be deduced from patients who rejected the surgery or those in whom the procedure was aborted. In a unique series of 394 patients who underwent exploration by laparotomy with the intent to carry out PE, 111 cases had to be aborted, mainly because of peritoneal spread or nodal involvement. The median overall survival after aborted procedures was only 8 months. The survival of patients in whom PE is not performed is mostly short, and their quality of life swiftly deteriorates because of pain, ureteral obstruction, bowel obstruction, and fistula formation.

References


Complications of Pelvic Exenteration

Pedro T. Ramirez | Gloria Salvo

Pelvic exenteration, the en bloc removal of the pelvic organs, is indicated for central recurrent or persistent gynecologic cancer, including cervical, endometrial, vaginal, or vulvar cancer. Even when performed in the setting of specialized centers by highly skilled surgeons, pelvic exenteration is associated with significant morbidity and mortality. Since the initial series published by Brunschwig in 1948, there has been a dramatic change in the type and frequency of the complications associated with this procedure. A number of factors have influenced the outcomes over the past several years, and these include the integration of broad-spectrum antibiotics, thromboembolic prophylaxis, vessel-sealing devices, multiteam surgical expertise, and critical care teams. In addition, modifications of urinary diversion and pelvic reconstruction procedures have paved the way to provide improved outcomes and lower complication rates. Nevertheless, this operation remains a challenge for all patients, and all involved with the care of the patient must recognize that it is a life-changing experience that affects physical, psychological, and sexual function and leads to major changes in quality of life. The report of a series by Maggioni and colleagues showed that the overall morbidity after pelvic exenteration was 66%, with 48% of patients having early complications (<30 days) and 48.5% of patients having late complications. The MD Anderson Cancer Center published a report on 160 patients who underwent pelvic exenteration for gynecologic malignancies and noted that the postoperative complication rate was as high as 94%, with 60% of all complications described as a potentially life-threatening event. The same group also noted a mortality rate of 1.3%. However, such variation may be secondary to the criteria set forth in the respective studies to define complications in the perioperative period. Overall, it is imperative to ensure careful patient selection, preoperative and postoperative care, and optimal surgical expertise in a tertiary cancer center to improve not only surgical outcomes but also survival for patients undergoing this procedure.

This chapter addresses the potential medical and surgical complications that may arise after pelvic exenteration. The emphasis is on the most common signs and symptoms, detection of such complications, and subsequent management options, highlighting surgical versus nonsurgical options. This chapter is intended as a reference guide to aid gynecologic oncologists in assessing the most common complications that arise after pelvic exenteration, and accordingly we do emphasize that appropriate consultation with indicated services is always encouraged.

Medical Complications

Febrile Morbidity

One of the most common postoperative complications in patients who have undergone pelvic exenteration is fever. Postoperative fever is defined as a temperature above 38°C (100.4°F) on 2 consecutive postoperative days or above 39°C (102.2°F) on any 1 postoperative day. The differential diagnosis is strongly influenced by the time of onset of the fever. The most common cause of fever within the first 48 hours is a pyretic response to the operation, and this is usually self-limiting. Studies have shown that the rate of febrile morbidity after pelvic exenteration can be as high as 71%. In the study by Westin and colleagues from MD Anderson, the rate of early sepsis (<60 days) was 8.8%, and the rate beyond this time point was 1.3%.

Among the most common causes of fever are the following:

- **Infectious**: Surgical site infection, pneumonia, urinary tract infection, and/or intravascular catheter–related infection
- **Noninfectious**: Hematoma or seroma, deep venous thrombosis (DVT) or pulmonary embolism (PE), inflammatory reaction (pancreatitis), vascular complication (hemorrhage, myocardial infarction, bowel ischemia or infarction), medications

After pelvic exenteration, sepsis may also be a great cause of morbidity and mortality. To be diagnosed with sepsis, a patient must have two of the following signs plus a confirmed infection: body temperature above 38.3°C (101°F) or below 36°C (96.8°F), heart rate higher than 90 beats per minute, and respiratory rate higher than 20 breaths per minute. Severe sepsis is diagnosed when a patient has one of the following: decreased urine output, abrupt changes in mental status, thrombocytopenia, dyspnea, myocardial dysfunction, or abdominal pain.

The routine workup of febrile morbidity should be targeted based on the organ system or infectious process of highest suspicion. The need for laboratory testing should be defined by the findings of a careful history and physical examination. The initial approach to the evaluation should include a complete blood count. Chest x-ray examination, urine cultures, and blood cultures are not indicated for all postoperative patients with fever. One should take into account the timing and the causes of fever. In patients with persistent febrile episodes after pelvic exenteration, one should proceed with abdominal and pelvic computed tomography (CT) scanning to rule out the potential possibility of an intraabdominal abscess.
Treatment for febrile morbidity should be tailored according to the source of the fever. Patients with persistent postoperative fever should be started on broad-spectrum antibiotics after cultures have been obtained. Coverage should be against aerobic gram-negative enteric bacilli and anaerobic organisms. If a source of fever is not apparent and blood cultures show no growth after 48 hours, then discontinuation of antimicrobials should be considered. If the cultures are positive, then antibiotic coverage should be focused on the known causative organism(s). All unnecessary treatments including medications, nasogastric tubes, and intravascular and urinary catheters should be discontinued, when possible, in the febrile patient.

In the setting of sepsis, all patients should be managed with broad-spectrum antibiotics, hemodynamic support such as crystalloids or albumin, vasopressor therapy, blood product administration, and mechanical ventilation, if needed. Discussion of goals of care and prognosis with the patient or family is paramount. Palliative care principles should be considered when appropriate.

**Thromboembolic Events**

**Incidence and Guidelines**

Among women undergoing major gynecologic surgical procedures without thromboprophylaxis, the risk of DVT ranges from 17% to 40%. This risk is even higher among women undergoing operation for gynecologic cancer. Martino and colleagues estimated the incidence of PE among 507 patients with known or suspected gynecologic cancer undergoing intraabdominal operations and found that the risk of postoperative PE in patients with a diagnosis of cancer was 14 times the risk of postoperative PE in those with benign disease.

Current guidelines for thromboprophylaxis are available from a number of groups, including the American College of Chest Physicians (ACCP), American Society of Clinical Oncology (ASCO), National Comprehensive Cancer Network (NCCN), and American College of Obstetricians and Gynecologists (ACOG). All of the aforementioned guidelines support the recommendation that all patients undergoing abdominal or pelvic surgical procedures for malignancy receive pharmacologic prophylaxis. The ASCO, NCCN, and ACOG guidelines recommend the consideration of continuing prophylaxis for up to 28 days after operation. The recommendation for extended prophylaxis in gynecologic cancer patients is derived from two randomized controlled trials indicating that prolonged thromboprophylaxis reduces the incidence of postoperative venous thromboembolism (VTE). The first study was a double-blind multicenter trial in which patients undergoing planned curative open procedures for abdominal or pelvic cancer received enoxaparin (40 mg subcutaneously) daily for 6 to 10 days. Patients were then randomly assigned to receive either enoxaparin or placebo for another 21 days. The results showed a 60% relative reduction and a 7% absolute reduction in the risk of postoperative VTEs in the prolonged thromboprophylaxis group. In a subsequent study, the investigators evaluated the efficacy and safety of thromboprophylaxis with low-molecular-weight heparin (LMWH) (dalteparin) administered for 28 days versus 7 days after major abdominal surgery for cancer. The results showed that the cumulative incidence of VTEs was reduced from 16.3% among patients receiving short-term thromboprophylaxis to 7.3% among patients receiving prolonged thromboprophylaxis.

In patients undergoing pelvic exenteration, the study by Westin and colleagues showed that the rate of thromboembolic events before 60 days was 1.9% and 5% beyond that time. In a study by Jurado and colleagues, the authors reported a rate of DVT among 45 patients who underwent pelvic exenteration of 11% and a rate of PE of 6.7%. Barakat and colleagues reported a mortality rate of 4.5% from PE after pelvic exenteration. It is interesting to note that in a study by Iglesias and colleagues, the authors showed that the rate of thromboembolic events was not affected by patient body mass index.

**Signs and Symptoms**

The most common symptoms associated with acute PE include dyspnea (73%), pleuritic chest pain (66%), cough (37%), and hemoptysis (13%). The most common signs are tachypnea (70%), rales (51%), tachycardia (30%), fourth heart sound (24%), accentuated pulmonic component of second heart sound (23%), and circulatory collapse (8%).

**Evaluation of Thromboembolic Events**

Once a medical history has been taken and physical examination performed, it is recommended that patients undergo a complete blood count, liver and kidney function tests, and chest radiography and electrocardiography as part of the initial evaluation. In patients with PE, the white blood cell (WBC) count may be normal or elevated, with a WBC count as high as 20,000 K/µL noted in some patients. A chest radiograph may be abnormal in most patients with PE, but the findings are not specific. Common radiographic abnormalities include atelectasis, pleural effusion, parenchymal opacities, and elevation of a hemidiaphragm. It is important to note that a normal-appearing chest radiograph in a patient with severe dyspnea and hypoxemia, but without bronchospasm or cardiac shunt, is strongly suggestive of PE. The most common electrocardiographic abnormalities in the setting of PE are tachycardia and nonspecific ST-T wave abnormalities.

It is important to note that the D-dimer test has limited usefulness in the setting of cancer and thus is not routinely recommended in the workup of thromboembolic events in such patients. Similarly, although arterial blood gas determination may show hypoxemia, hypocapnia, and respiratory alkalosis in patients with a PE, it is not routinely used because of its very low predictive value.

The diagnostic study of choice for DVT is compression ultrasonography. When a DVT is present, the veins do not collapse when pressure is applied. However, it is important to note that a negative ultrasonic Doppler result does not rule out DVT, because a number of DVTs may occur in areas that are inaccessible to the ultrasonic evaluation. For the diagnosis of PE, the ideal choice of study is computed tomographic pulmonary angiography (Fig. 16.1). This is for patients with a suspected diagnosis of PE and who are hemodynamically stable. However, in patients who are not stable, bedside echocardiography may be used to obtain a presumptive diagnosis to justify the administration of potentially lifesaving therapies. Ventilation-perfusion (V/Q) scanning may be used when CT scanning is not available or if the patient has a contraindication to CT scan or use of intravenous contrast material. Brain natriuretic peptides (BNPs) are neither sensitive (60%) nor specific (62%); however, patients with PE tend to have higher BNP levels. Elevated levels tend to be associated with increased risk of subsequent...
complications and mortality in patients with PE. BNP testing is not routinely recommended as part of the standard evaluation of PE.

**Treatment of Thromboembolic Events**

The approach to a patient with a thromboembolic event is to ensure that the patient’s condition has been stabilized after assessment of hemodynamic stability. The first steps should be to provide adequate oxygen supplementation (targeting $\text{O}_2$ saturation $\geq 90\%$), obtain peripheral intravenous access, and begin empiric anticoagulation. The ACCP guidelines recommend starting LMWH or subcutaneous heparin. Once-daily treatment is the preferred choice. The length of anticoagulation for DVT is 3 months, and the recommended length of therapy for PE is 6 months. The ACCP guidelines recommend that thrombolytic therapy should be used in patients with acute PE associated with hypotension (systolic blood pressure BP below 90 mm Hg) who do not have a high risk of bleeding. Embolectomy is recommended in patients with massive PE who have a contraindication to fibrinolysis or who remain unstable after receiving fibrinolysis. It may also be considered in patients with evidence of right ventricular enlargement or dysfunction on transthoracic echocardiogram. Inferior vena cava filters are indicated in the setting of patients with an absolute contraindication to anticoagulant therapy (hemorrhagic stroke or active bleeding). It is also indicated when recurrent embolism is present even after adequate anticoagulant therapy.

**Acute Renal Events**

Acute kidney injury (AKI) is the abrupt loss of kidney function, resulting in the retention of urea and other nitrogenous waste products and in the dysregulation of extracellular volume and electrolytes. This term has replaced acute renal failure (ARF) after consideration that even small decrements in kidney function are of substantial clinical relevance and are associated with increased morbidity and mortality. In the study by Westin and colleagues, the authors reported that the rate of ARF or AKI after pelvic exenteration was 3.8%.

AKI has multiple possible causes, and it is most commonly due to acute tubular necrosis (ATN) from ischemia, nephrotoxin exposure, or sepsis. Other frequent causes include volume depletion, urinary obstruction, rapidly progressive glomerulonephritis, and acute interstitial nephritis. AKI is typically detected by means of an increase in serum creatinine and/or a decrease in urine output. Among hospitalized patients, ATN and prerenal disease are the most common causes.

Several consensus definitions of AKI have been developed to provide a uniform definition of AKI. The RIFLE criteria are described here; they consist of three graded levels of kidney dysfunction (risk, injury, and failure), based on the magnitude of increase in serum creatinine or urine output, and two outcome measures (loss and end-stage renal disease [ESRD]). The RIFLE strata are described in Table 16.1.

It has been shown that, compared with patients who did not have AKI, patients in the RIFLE stages of “risk,” “injury,” and “failure” had increased relative mortality risks of 2.4 (confidence interval [CI], 1.94–2.97), 4.15 (CI, 3.14–5.48), and 6.37 (CI, 5.14–7.9), respectively.

**Initial Evaluation After Diagnosis**

All patients with AKI must be carefully evaluated both for reversible causes (hypotension, volume depletion, or obstruction) and for the presence of complications (volume overload, hyperkalemia, metabolic acidosis, hypocalcemia, and hyperphosphatemia). The initial evaluation of the patient with AKI is directed at determining the cause and identifying the complications that may require immediate attention. The timing of onset often suggests the underlying cause. A careful review of medications is imperative. Often, nephrotoxic medications have been started before the onset of AKI, which suggests a cause. In addition, even long-standing medications (particularly angiotensin-converting enzyme [ACE] inhibitors or angiotensin receptor blockers) render patients vulnerable to AKI from prerenal factors or ATN.

**Patient Evaluation**

The initial assessment should include the careful evaluation of volume status and measurement of serum electrolytes, particularly potassium and bicarbonate, and serum phosphate, calcium, and

---

**Table 16.1 RIFLE Criteria for Acute Renal Compromise**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Risk</strong></td>
<td>1.5-fold increase in the serum creatinine, or glomerular filtration rate (GFR) decrease by 25%, or urine output $&lt;0.5\text{mL/kg/h}$ for 6 h</td>
</tr>
<tr>
<td><strong>Injury</strong></td>
<td>Twofold increase in the serum creatinine, or GFR decrease by 50%, or urine output $&lt;0.5\text{mL/kg/h}$ for 12 h</td>
</tr>
<tr>
<td><strong>Failure</strong></td>
<td>Threefold increase in the serum creatinine, or GFR decrease by 75%, or urine output of $&lt;0.3\text{mL/kg/h}$ for 24 h, or anuria for 12 h</td>
</tr>
<tr>
<td><strong>Loss</strong></td>
<td>Complete loss of kidney function (e.g., need for renal replacement therapy) for more than 4 weeks</td>
</tr>
<tr>
<td><strong>End-stage renal disease</strong></td>
<td>Complete loss of kidney function (e.g., need for renal replacement therapy) for more than 3 months</td>
</tr>
</tbody>
</table>
albumin. One should also check serum uric acid and magnesium and perform a complete blood count. Initial testing should include reagent strip urinalysis (dipstick) with automated urine microscopy and the quantification of urine protein or albumin (by random or “spot” protein-to-creatinine ratio or albumin-to-creatinine ratio).

A physical examination may reveal the cause. Signs of volume contraction suggest a prerenal cause of AKI. An ultrasound examination could be an option if renal function does not improve; ultrasonography is the most commonly used imaging technique in patients with AKI. Ultrasonography is safe, easy to perform, and sensitive for obstruction. Magnetic resonance imaging (MRI) with gadolinium should be avoided in patients with AKI because of the nephrotoxicity of the agent. In patients with moderate to advanced kidney disease with estimated glomerular filtration rate (eGFR) below 30 mL/min, the administration of gadolinium has been associated with the potentially severe syndrome of nephrogenic systemic fibrosis (NSF).

The results of the urinalysis and ultrasound examination generally direct the remainder of the diagnostic evaluation. Patients who have evidence of obstruction require further investigation and usually intervention to relieve the obstruction and determine the cause. For patients who have normal renal imaging findings, minimal proteinuria, benign urine sediment on urinalysis and microscopy (no red cells or cellular casts), and no clear explanation for AKI, further evaluation is determined by the severity of disease and rate of further decline.

- If the creatinine level is persistently elevated or if an initially mild increase in the creatinine level worsens over the course of days, then a kidney biopsy should be performed. A biopsy is often performed when the diagnosis is uncertain. A biopsy usually enables a more definitive tissue diagnosis and may allow a therapeutic intervention to prevent ESRD.
- In patients who have signs and symptoms of rapidly progressive or unexplained systemic disease, a renal biopsy is warranted, even if the eGFR remains stable after initial increase.
- In patients who have mild decrements in eGFR (e.g., to 45 to 60 mL/min/1.73 m²) where the eGFR subsequently remains stable, one should just follow the serum creatinine. If the creatinine level remains stable, one should continue to follow creatinine level, the results of urine studies (urinalysis, microscopic studies, urine protein and creatinine), and blood pressure until a clear temporal pattern has been established.

Urinalysis
The urinalysis involves both use of a urine dipstick and microscopic examination of the urine sediment. The dipstick can be used to test for protein (albumin), pH, glucose, hemoglobin (or myoglobin), leukocyte esterase (reflecting pyuria), and specific gravity.

Urine Sodium Excretion
The fractional excretion of sodium (FENa) measures the percent of filtered sodium that is excreted in the urine.

- The FENa is commonly used to assist in differentiating prerenal disease (a reduction in glomerular filtration rate [GFR] due solely to decreased renal perfusion) from ATN, the two most common causes of AKI.
- In patients with suspected prerenal disease or ATN, it is recommended that the FENa be measured. A value of the FENa below 1% commonly indicates prerenal disease; in comparison, a value between 1% and 2% may be seen with either disorders, and a value above 2% usually indicates ATN.

Urine Volume
Trends in and comparisons between the volumes of fluid going into and coming out of a patient (including urine output) are helpful physiologic parameters in patients with AKI. Oliguria (typically defined as <0.3 mL/kg/h or <500 mL/day of urine output) may or may not occur in patients with AKI. Normal urine output can be maintained even with an abnormally low GFR in patients with nonoliguric ATN. The prognosis of non-oliguric AKI is generally better than that of oliguric or anuric disease.¹⁹,²⁰

Management

Volume Issues
An assessment of volume status is performed in all patients with AKI because correction of volume depletion or volume overload (especially when associated with worsening cardiac output) may reverse or ameliorate AKI.

Volume Depletion
Unless contraindicated, the patient with a clinical history consistent with fluid loss (such as vomiting and diarrhea), physical examination findings consistent with hypovolemia (hypotension and tachycardia), and/or oliguria should receive intravenous fluid therapy. This fluid challenge attempts to identify prerenal failure that can progress to AKI if not treated promptly. Studies have shown that prompt reversal of volume depletion may prevent or limit kidney injury due to ATN. However, such fluid infusion is contraindicated in those with obvious volume overload or heart failure. Fluids may be either crystalloid or colloid. One should begin with 1 to 3 L of fluid, with careful and repeated clinical assessment to evaluate the patient's response to this therapy. Fluid therapy should be targeted to physiologic end points.

Volume Overload
Hypervolemia may be present at initial evaluation or may occur because of excessive fluid administration in the setting of impaired ability to excrete sodium and water. This is especially true for patients with sepsis, who commonly receive aggressive intravenous fluid resuscitation.

Hyperkalemia
Hyperkalemia is a common and potentially life-threatening complication of AKI. In general, all patients with AKI and hyperkalemia that is refractory to medical therapy should be dialyzed unless hyperkalemia is mild (i.e., <5.5 mEq/L) and the cause of AKI is known to be easily reversed (such as prerenal AKI due to volume depletion or ACE inhibitors).

Prognosis
Most patients with AKI recover renal function, with recovery manifesting with an increase in urine output and a gradual decrease in the blood urea nitrogen (BUN) and serum creatinine concentration. However, in many patients, including those with previously normal renal function, renal function does not return to baseline levels. In addition, many studies have demonstrated an increase in the risk of chronic kidney disease (CKD) and ESRD in patients who recover from AKI. Even small, acute rises in serum creatinine as low as 0.3 mg/dL (27 μmol/L) are associated with both short-term and long-term increases in mortality.
Chapter 16 Complications of Pelvic Exenteration

Surgical Complications

Wound-Related Events

Superficial Wound Separation

A frequent complication in patients who undergo pelvic exenteration is wound complication. The rate of such complications has ranged from 5.6% to 29.4% in the largest published series. However, one must consider that these include both abdominal wound complications and perineal wound issues.2–4

Dehiscence and Evisceration

Complete fascial dehiscence is associated with a mortality rate of 10%. Early postoperative fascial dehiscence is a surgical emergency and should be addressed promptly. The risk factors for fascial disruption are advanced age, chronic pulmonary disease, anemia, postoperative coughing, wound infection, and complexity of surgery. Other factors include malignancy, obesity, sepsis, hypoalbuminemia or poor nutrition, and chronic glucocorticoid therapy. Herniation is more common when the incision length exceeds 18 cm.21 Dehiscence is most likely due to placement of the suture too close to the edge or under tension. To minimize this complication, elective midline abdominal closure should be performed with continuous absorbable sutures.

Signs and symptoms of complete dehiscence include profuse serosanguineous drainage, fever, and abdominal pain. Most dehiscences occur 4 to 14 days after operation. The diagnosis is made primarily based on clinical suspicion. Ultrasonography or CT may be used when the diagnosis is not clear (Fig. 16.2). Once the diagnosis has been confirmed, one should place a moist dressing over the wound at the bedside. When the patient is taken to surgery, the surgeon should perform complete wound opening and subsequent debridement of the fascial edges while ensuring that no bowel injury occurs during the procedure. A mass closure with continuous delayed absorbable sutures should be performed. However, if the fascial defect that remains after proper debridement is too large, use of a wound mesh should be considered.

Necrotizing Fasciitis

Necrotizing fasciitis is a rare, life-threatening soft tissue infection primarily involving the fascia and subcutaneous tissue. The reported mortality of necrotizing fasciitis ranges from 20% to 80%.22 There are three types of necrotizing fasciitis. These are:

- Type I—This is a mixed infection caused by both anaerobic and aerobic species. Risk factors include diabetes, peripheral vascular disease, immune compromise, or recent operation.
- Type II—This is generally a monomicrobial infection caused by group A streptococci or other β-hemolytic streptococci, either alone or in combination with other species, most commonly Staphylococcus aureus.
- Type III—This is also known as “gas gangrene” and is caused by the organism Clostridium perfringens.

Clinical symptoms include erythema, swelling, changes in skin coloring, intense pain that may be disproportionate to the skin findings, subcutaneous emphysema, fever, nausea, vomiting, and/or malaise. It may often be misdiagnosed as cellulitis or abscess. On physical examination, the patient may appear deceptively well; however, this may significantly delay the diagnosis. Such delay will lead to a rapid deterioration of the patient’s condition, and the patient will suddenly demonstrate a toxic appearance. The redness quickly spreads, with the margins moving rapidly into normal skin near the site of the incision. The skin will then develop a dusky or purplish discoloration, subsequently leading to large areas of gangrenous skin. Ultimately, anesthesia in the involved region may be reflective of the fact that there is thrombosis to the subcutaneous blood vessels that leads to necrosis of the nerve fibers. Local crepitation can occur; however, this is not a common finding.

Necrotizing fasciitis remains a clinical diagnosis. Imaging studies may be useful to determine whether muscle tissue is involved but should not delay surgical intervention. Early

FIG. 16.2. Computed tomography scan of abdomen and pelvis with contrast ([A] axial and [B] sagittal planes) showing anterior abdominal fascial dehiscence with evisceration.
radiographic findings include soft tissue thickness and opacity. CT scans may show dermal thickening, increased soft tissue attenuation, inflammatory fat stranding, and possible superficial or deep crescentic fluid or air in the subfascial planes.\textsuperscript{23}

The treatment of patients with necrotizing fasciitis consists of adequate and aggressive surgical debridement, supportive care, and broad-spectrum antibiotics. Surgical exploration is the only way to definitely establish the diagnosis. At operation the findings will reveal that the normal skin and subcutaneous tissue become loosened from the rapidly spreading deep necrotic fascia. It is important to note that fascial necrosis is usually more advanced than the appearance suggests. Without prompt treatment, secondary involvement of the deeper muscle layers may occur, resulting in myositis or myonecrosis. It is important to recognize that surgical debridement is associated with a lower mortality when performed within 24 hours of diagnosis.\textsuperscript{24}

**Urinary Diversion Complications**

During a total or anterior pelvic exenteration, urinary diversion is routinely performed. Patients can choose either continent or incontinent urinary diversion, and there are advantages and disadvantages associated with both of these techniques. Incontinent diversion is faster and less technically challenging than continent diversion; also, incontinent diversion may have the advantage of requiring less maintenance effort and self-care by the patient. The incidences of early and late complications of incontinent urinary diversion have been reported to be 33% and 28%, respectively.\textsuperscript{25} The most commonly reported complications are anastomotic leakage (3%), fistula formation (3%–19%), need for reoperation (8%–19%), renal insufficiency (6%–17%), urostomy stricture (7%), and ureteral obstruction (7%) (Fig. 16.3).

Continent urinary diversion offers better cosmetic results than incontinent diversion; however, overall complication rates with continent diversion remain significant and range from 37% to 66%. The most common complications associated with continent urinary diversion are pyelonephritis (13%–42%), difficulty with catheterization (12%–54%), ureteral (anastomotic) stricture (2%–22%), urostomy stricture (4%–22%), incontinence (7%–13.3%), urinary stone formation (7%–18%) (Fig. 16.4), ureteral (anastomotic) leaks (2%–14%), fistula (2%–15%), and permanent renal failure (3%). There is also the potential risk of development of hyperchloremic metabolic acidosis.

In a study by Ramirez and colleagues\textsuperscript{26} from MD Anderson Cancer Center, the authors reported on 133 patients who underwent total pelvic exenteration. Ninety-nine patients (74.4%) underwent a total pelvic exenteration, and 34 (25.6%) underwent an anterior pelvic exenteration. In 46 patients (34.6%), continent urinary diversion was performed, and continent urinary diversion was performed in 87 patients (65.4%). The mean age at exenteration was 47.6 years (range, 30–73 years) in the continent urinary diversion group and 57.2 years (range, 27–86 years) in the incontinent urinary diversion group ($P < .0001$). Median follow-up time after exenteration was 28.5 months (range, 2.3–185.7 months) for patients with continent urinary diversion and 28.1 months (range, 1.4–187.1 months) for patients with incontinent urinary diversion. The most common postoperative complication was pyelonephritis or urosepsis, which occurred in 32.6% of the patients with continent urinary diversion and 37.9% of the patients with incontinent urinary diversion ($P = .58$). The second most common complication was urinary stone formation, which occurred in 34.8% of the patients with continent urinary diversion and 2.3% of the patients with incontinent urinary diversion ($P = .001$). No stone formation was observed in the first 60 days after continent urinary diversion. Of the 16 patients with stone formation and continent urinary diversion, 11 were asymptomatic and did not require intervention. Three patients underwent laparotomy for stone removal—one because of an enterocutaneous (pouch-to-skin) fistula, possibly secondary to infection and an obstructive mucous plug, and the other two because of large size (one patient) and number of stones ($n = 1$). One patient had bilateral nephrostomy tubes placed because of urinary obstruction and poor functional status, and one patient was treated successfully with cystolitholapaxy. Both patients with stone formation and incontinent urinary diversion were asymptomatic and did not require intervention.

No significant differences were observed between the continent and incontinent urinary diversion groups for rates of ureteral (anastomotic) leakage, ureteral (anastomotic) stricture, renal insufficiency, fistula formation, conduit reoperation, or pyelonephritis or urosepsis. No statistical significance in urostomy stricture formation was found after multivariate analysis ($P = .08$). In patients with at least one episode of pyelonephritis or urosepsis, there was no significant difference between the groups ($P = .20$). There was also no significant difference between the groups for the number of hospitalizations required because of complications related to the urinary diversion ($P = .45$). When the analysis was limited to patients who had received preoperative pelvic radiation, there was an increased incidence of urostomy stricture after 60 days in patients with continent urinary diversion on univariate analysis. Of the patients with continent urinary diversion, 28.3% reported incontinence, and 15.2% reported difficulty with catheterization.

In that study, the authors concluded that patients undergoing pelvic exenteration have a high risk of complications and that there is no difference in postoperative complication rates related to urinary diversion except that urinary stone formation is more common among patients with a continent urinary diversion. Continent urinary diversion is also associated with the potential for additional complications: incontinence and difficulty with catheterization.

**Bowel-Related Complications**

Patients undergoing a pelvic exenteration are at a higher risk of developing postoperative bowel complications as a result of various factors that affect healing, such as poor nutritional status and prior history of radiation therapy. It has been shown that the rate of bowel-related complications after pelvic exenteration is approximately 10%.\textsuperscript{3,4}

**Postoperative Ileus**

Postoperative paralytic ileus refers to obstruction and intolerance of oral intake due to nonmechanical factors that disrupt the normal coordinated propulsive motor activity of the gastrointestinal tract following abdominal or nonabdominal surgical procedures. After abdominal operation, “normal” physiologic postoperative ileus due to postoperative gut dysmotility is widely reported as lasting 0 to 24 hours in the small intestine, 24 to 48 hours in the stomach, and 48 to 72 hours in the colon.\textsuperscript{27} The multiple definitions of “prolonged” postoperative ileus have included:

- No return of bowel function postoperatively (ranging from postoperative days 4 to 6)
- Absence of flatus or stool by postoperative day 6
Chapter 16
Complications of Pelvic Exenteration

- Postoperative nausea or vomiting necessitating cessation of oral intake, intravenous support, or nasogastric tube placement by postoperative day 5
- Return of bowel function after postoperative day 5
- Absence of flatus and/or bowel movement prolonging hospitalization beyond discharge goal (ranging from postoperative days 6 to 8)
- Lack of bowel activity more than 5 days after operation

Among the most common nonsurgical risk factors are opioid use, antihypertensive agents, antidiarrheal or antiemetic agents, any drug with an anticholinergic property, muscle relaxants, and atropine products. There are also a number of medical conditions that may predispose the patient to postoperative ileus. These include pancreatitis, gastroenteritis, spinal cord injury, myocardial infarction, stroke, pneumonia, diabetes, diabetic ketoacidosis, botulism, or Parkinson disease. When considering surgical factors, one must consider that lower abdominal procedures with large incisions and with intestinal manipulation (e.g., colorectal, gynecologic [exenteration]) are associated with a higher risk of postoperative ileus, whereas abdominal procedures with smaller incisions and minimal visceral manipulation (e.g., cholecystectomy) are associated with a lower risk.

The most common symptoms are abdominal distention, bloating, diffuse abdominal pain, nausea and/or vomiting, inability to pass flatus, and inability to tolerate a regular oral diet. On examination, the patient may have abdominal distention and a tympanic abdomen with reduced bowel sounds and some degree of tenderness.

The diagnosis is established based on clinical findings and plain abdominal films. These may show dilated loops of bowel

**FIG. 16.3** (A) Digital subtraction angiogram showing filling of the conduit without evidence of leakage of the right ureteral anastomosis (normal right ureter drainage). (B) Left posterior oblique view demonstrating contrast leaking from left ureter into the pelvis (arrows). (C) Computed tomography scan of the abdomen and pelvis with contrast. Urinary leak at ureteric anastomosis with the ileal conduit in the posterior left pelvis.
but with evidence of air in the colon and rectum without a transition zone that would suggest bowel obstruction (Fig. 16.5A). There should not be any evidence of free air that is associated with perforation. The diagnosis is established when the signs and symptoms persist for more than 3 to 5 days. When in doubt, CT of the abdomen will help differentiate small bowel obstruction from ileus, given that it has a sensitivity and specificity of 90% to 100%.

Therapy for patients with postoperative ileus should focus on removal of any recognized inciting factors, maintenance and replacement of fluid therapy, electrolyte replacement, bowel rest and bowel decompression (as needed), and serial abdominal examinations.

**Bowel Obstruction**

Small bowel obstruction can be functional or mechanical. The small bowel is involved in about 80% of cases of mechanical bowel obstruction. There are several causes for small bowel obstruction; however, in the postoperative period after pelvic exenteration, the most common cause of small bowel obstruction is adhesion formation. It is imperative to diagnose the bowel obstruction early so that the appropriate management may be initiated. In simple mechanical obstruction, blockage occurs without vascular compromise. The normal secretory and absorptive functions of the mucosa are depressed, and the bowel wall becomes edematous and congested. There may also be transudative loss of fluid from the intestinal lumen into the peritoneal cavity. Electrolyte loss is common in this setting, leading to metabolic alkalosis, and the fluid loss may result in hypovolemia. If the bowel obstruction is not recognized and properly addressed, the obstruction will lead to vascular compromise, and the blood flow to the bowel will diminish. Venous obstruction occurs first, followed by arterial occlusion, resulting in rapid ischemia of the bowel wall. The ischemic bowel becomes edematous and infarcts, leading to gangrene and perforation. Acute mechanical small bowel obstruction is a common surgical emergency.

**Signs and Symptoms**

Patients with bowel obstruction may have an abrupt onset of abdominal pain, nausea, vomiting, cramping, and abdominal distention. Patients with partial obstruction may have intermittent episodes of diarrhea; however, more commonly, patients with complete obstruction will have obstipation at presentation. One should note that the presence of diarrhea in the setting of bowel obstruction does not automatically indicate resolution of the obstruction. At inspection of the abdomen, the physical examination may reveal evidence of distention, hyperactive bowel sounds secondary to high-pitched peristalsis, and tenderness. In multiple retrospective reviews, abdominal distention was the most frequent physical finding on clinical examination, occurring in 56% to 65% of patients. With significant bowel distention, bowel sounds may become muffled, and as the bowel distention progresses, the bowel sounds may become hypoactive. The degree of tenderness is dependent on the level of obstruction and whether there is evidence of bowel ischemia. Fever may be associated with complications of obstruction such as ischemia or necrosis.

**Diagnosis**

In general, the diagnosis of small bowel obstruction is a clinical and radiologic diagnosis. The initial evaluation should include supine and upright abdominal radiographs. X-ray findings are diagnostic in 50% to 60% of patients; equivocal in about 20% to 30%; and normal, nonspecific, or misleading in 10% to 20%. The key radiographic signs that allow distinction between a high-grade small bowel obstruction and a low-grade obstruction are the presence of small bowel distention, with maximal dilated loops averaging 36 mm in diameter and exceeding 50% of the caliber of the largest visible colon loop, in addition to a 2.5-times increase in the number of distended loops in the abdomen compared with the normal number. Other findings that are most significant and predictive of high-grade small bowel obstruction are the presence of more than two air-fluid levels, air-fluid levels wider than 2.5 cm, and air-fluid levels differing more than 2 cm in height from one another within the same small bowel loop. It is often difficult to differentiate postoperative ileus from an obstruction based solely on findings on abdominal radiographs. In that setting, a definitive diagnosis is attained based on both clinical suspicion and CT scan findings (see Fig. 16.5B and C). It should be noted that in patients with necrosis or gangrene, the abdominal imaging may demonstrate gas in the bowel wall, also known as pneumatosis intestinalis (Fig. 16.6). This is an ominous sign and a surgical emergency because imminent bowel perforation is usually seen in this setting.

Standard CT is the ideal imaging modality for evaluation of small bowel obstruction, with sensitivity of 90% to 96%, specificity of 96%, and accuracy of 95%. Newer multidetector CT scanners with multiplanar reformation capability are considered more effective in evaluation of small bowel obstruction. Therefore, CT is considered the best modality for determining which patients would benefit from conservative management and close follow-up and which patients would benefit from immediate surgical intervention. CT criteria for small bowel obstruction are the presence of dilated small bowel loops (diameter >2.5 cm from outer wall to outer wall) proximally to normal-caliber or collapsed loops distally. It should be noted that multidetector CT usually does not require oral contrast material because the retained intraluminal fluid serves as a natural...
negative contrast agent, and it allows assessment of extramural areas that would not be visible at contrast-enhanced studies.

If CT scan is unavailable, sonography can sometimes serve as a useful substitute. Sonography is not commonly used for the evaluation of small bowel obstruction, mainly because most of the time the bowel loops are filled with gas, producing nondiagnostic sonograms, and because adhesions, the most common cause of mechanical small bowel obstruction, are not detected with this technique. However, when the obstructed bowel segments are dilated and filled with fluid, not only can the level of obstruction be recognized but the cause of the obstruction can also be demonstrated with the use of the fluid-filled bowel as a sonic window.

Treatment

Aggressive intravenous fluid therapy and correction of electrolyte imbalance are crucial in the initial management of acute small bowel obstruction. A Foley catheter and occasionally a central venous catheter are needed to monitor fluid resuscitation. Blood tests identify electrolyte imbalance, elevated leukocyte count, abnormal liver function test results, elevated amylase level, acidosis, anemia, and bleeding tendency. A nasogastric tube allows decompression of the stomach and prevents aspiration. Traditionally, it has been recommended that patients with small bowel obstruction (without indications for immediate surgical exploration) should be observed for no longer than 12 to 24 hours, after which time, if no improvement is seen, the patient should undergo exploration. However, as long as there remain no findings on serial clinical evaluation to suggest a complicated obstruction, the patient may be observed for a longer period of time. Repeated examination of the patient during this period is extremely important.

Data regarding nonoperative management suggest it to be successful in 65% to 81% of partial small bowel obstruction.

**Fig. 16.5** (A) Air-fluid levels (arrows) consistent with postoperative ileus. (B) Prominent small bowel loops consistent with distal small bowel obstruction (yellow line). (C) Computed tomography scan of the abdomen and pelvis. Small bowel obstruction with evidence of transition point (arrow).
cases. All patients suspected of having complicated bowel obstruction (complete obstruction, closed-loop obstruction, bowel ischemia, necrosis, or perforation) based on clinical and radiologic examination should be taken to the operating room for abdominal exploration (Fig. 16.7). It should be noted that for patients who ultimately require an operation, a delay of more than 1 day has been identified as a risk factor for requiring bowel resection.\(^\text{15}\) (Fig. 16.8).

**AnastomoticLeaks**

The overall incidence of anastomotic leaks is approximately 2% to 7%.\(^\text{36}\) The lowest leak rates are found with ileocolic anastomosis (1%–3%), and the highest rates are found in coloanal anastomosis (10%–20%).\(^\text{37}\) The mortality rate for an anastomotic leak in the literature typically is in the 10% to 15% range.\(^\text{38}\) In the study by Maggioni and colleagues,\(^\text{2}\) the rate of leaks in patients undergoing pelvic exenteration was 2.8%. In the setting of pelvic exenteration, the anastomotic leak usually occurs as a result of small bowel anastomosis when a segment of ileum is used as the incontinent urostomy. The anastomotic leak may also be seen in the setting of ileocolonic anastomosis when a continent conduit is performed after the distal ileum and ascending colon have been used for the urinary conduit.

Most anastomotic leaks usually become apparent 5 to 7 days postoperatively. The majority of the literature defines

---

**FIG. 16.6** Computed tomography scan of the abdomen and pelvis (coronal [A] and axial [B] views). Air in small bowel wall consistent with pneumatosis intestinalis (red arrows) and closed-loop obstruction of small bowel (yellow arrow).

**FIG. 16.7** Pneumoperitoneum demonstrating free air within abdominal cavity. (A) Abdominal radiograph. (B) Computed tomography scan of the abdomen and pelvis (arrow).
anastomotic leak with use of clinical signs, radiographic findings, and intraperitoneal findings. Clinical signs include pain, fever, tachycardia, peritonitis, feculent drainage, or purulent drainage. The radiographic signs include fluid collections and gas-containing collections. CT scan appears to be the most helpful radiographic study, given that contrast enemas fail to identify the leak 60% of the time (Fig. 16.9). The intraoperative findings include gross enteric spillage and anastomotic disruption.

The common risk factors for intraperitoneal anastomotic leaks are American Society of Anesthesiologists (ASA) status 3 to 5, emergent surgery, prolonged operative time (>4 hours), and hand-sewn anastomosis. In patients undergoing pelvic exenteration, there is also the added risk of prior radiation therapy. It is unclear if drains placed at the time of operation lead to an increased risk of anastomotic leaks. The role of mechanical bowel preparation is also controversial. A meta-analysis of 14 prospective trials found no significant difference in overall anastomotic leak rate for patients with bowel preparation compared with those without it. Nutritional factors including hypoalbuminemia, alcohol intake, and weight loss have shown variable and conflicting results. There remains a controversy regarding whether a protective ileostomy is necessary when bowel anastomosis is performed. Several studies have found that patients with protective stomas had significantly lower rates of leaks that require surgical intervention. However, one must note that most studies evaluating protective ileostomy are in the setting of low-rectal anastomosis for colon surgery. Similarly, data are inconsistent in determining the relationship between perioperative corticosteroid use and risk of anastomotic leaks.

Management
Once the leak has been recognized, the patient should receive intravenous fluid resuscitation and broad-spectrum antibiotics. Management strategies include observation, bowel rest, percutaneous drainage, surgical revision, or diversion. The ultimate management is dependent on the patient's clinical condition. A subclinical leak is defined as a leak detected radiographically in patients with no clinical abdominal findings and can be managed expectantly. For patients with localized peritonitis and low-grade sepsis, a diagnostic imaging evaluation is performed. When a leak is present, the majority will be localized. If the patient's condition is stable and a small, contained abscess (<3 cm) is present, one may consider conservative management with broad-spectrum antibiotics and bowel rest. For larger abscesses (>3 cm), multiloculated collections, or multiple collections, one should attempt percutaneous drainage (Fig. 16.10). If a free intraperitoneal leak is demonstrated, it is recommended that the patient be taken to the operating room for surgical intervention.
Skin Irritation

Peristomal skin complications are common in patients with a stoma. The frequency ranges from 18% to 55%. There is a broad range of presentations, from mild skin irritation to ulceration and concomitant infection (Fig. 16.11). The greatest risk factor is noted in patients with difficult-to-fit stomas. Often other associated stomal complications are noted, such as prolapse, retraction, and parastomal hernias. Obese patients are particularly at risk for skin complications owing to difficulty in fitting stoma appliances around body folds. These complications are more commonly seen in poorly constructed and poorly located stomas.

Mechanical, chemical, allergic, and infectious causes have been identified. Most mechanical injuries occur from improper fitting or changing of an ostomy appliance. Frequent appliance changes lead to mechanical stripping of the surrounding epidermis. Painful denuded areas of skin develop, typically in the distribution of contact with adhesives. Applying a skin sealant to the damaged area can assist healing and prevent further skin stripping. Pressure injuries occur from tightly fitting ostomy belts or use of convex flanges. Ulcers can form, at times full thickness, at pressure points. Movement of such devices against the skin also causes shear injury. Topical wound care products can be used to treat the damaged peristomal skin. Ideally, the offending device (ostomy belt or convex flange) should be discontinued; however, the patient may require these devices for an adequate seal. Chemical injuries occur from exposure of the peristomal skin to the intestinal effluent. Often the skin will appear reddened and moist. The extent of the injury will depend on the effluent, with small bowel content being the most caustic, as well as the duration of exposure. Irritant contact dermatitis is the most common peristomal skin complication. Preventing progression is critical because the dermatitis can lead to worsening leakage, further irritation and pain, and an ongoing vicious circle. It is not uncommon for patients and inexperienced caregivers to create progressively larger wafer openings in an attempt to alleviate the skin irritation. This practice only worsens the lesion as the skin is persistently exposed to chemical injury. Such practices should be quickly recognized and promptly discouraged. Eroded peristomal skin can be treated with a hydrocolloid powder before placement of the stoma appliance. Routine stoma care and a well-fitting stoma appliance that covers the injured skin will allow the peristomal skin to heal. Peristomal skin with repeated exposure to effluent may develop pseudoverrucous lesions. Treatment for this condition is similar to that for irritant contact dermatitis (appliance refitting and local skin care), and the pouch should be fitted to cover the lesions. An allergic contact dermatitis can occur in patients sensitive to the stoma appliance adhesive or any powders, barrier, or fillers. As with irritant contact dermatitis, patients will have erythematous skin with vesicles. The two entities can be distinguished based on the pattern of distribution. Allergic dermatitis will occur where the adhesive or offending agent contacts the skin, whereas irritant dermatitis will occur at the site of effluent leakage. Removal of the irritating agent will allow the skin to heal. A patch test of possible irritants may be helpful. Topical corticosteroids or antihistamines may help the peristomal skin recover. The warm, moist, and dark environment of the peristomal skin places it at high risk for infection. Cutaneous candidiasis is the most common peristomal skin infection. Cutaneous candidiasis manifests as shiny and reddened skin with pustules. An immunocompromised state or recent antibiotic use places the patient at higher risk. Most often, however, the infection can simply be

stomal complications

The creation of intestinal stomas is a key element in performing a pelvic exenteration. Complications of stoma formation remain common, despite extensive measures aimed at reducing them. Stomal herniation or retraction is not a routinely reported complication of pelvic exenteration; however, it can lead to significant psychological and financial burden. The most common stomal complications include improper selection of stoma site; vascular compromise; retraction; herniation; peristomal skin irritation; peristomal infection, abscess, fistula, and peristomal bleeding; and bowel obstruction. The rate of stomal complications ranges from 6% to 59%. Risk factors are based on patient-, operation-, and disease-specific issues. The most common patient-specific issues include age, sex, body mass index, nutritional status, ASA status, and corticosteroid use. Operation-specific factors include emergency versus elective procedures. Disease-specific factors include history of respiratory comorbidities, smoking, diabetes, and cancer.

Stomal Complications

The creation of intestinal stomas is a key element in performing a pelvic exenteration. Complications of stoma formation remain common, despite extensive measures aimed at reducing them. Stomal herniation or retraction is not a routinely reported complication of pelvic exenteration; however, it can lead to significant psychological and financial burden. The most common stomal complications include improper selection of stoma site; vascular compromise; retraction; herniation; peristomal skin irritation; peristomal infection, abscess, fistula, and peristomal bleeding; and bowel obstruction. The rate of stomal complications ranges from 6% to 59%. Risk factors are based on patient-, operation-, and disease-specific issues. The most common patient-specific issues include age, sex, body mass index, nutritional status, ASA status, and corticosteroid use. Operation-specific factors include emergency versus elective procedures. Disease-specific factors include history of respiratory comorbidities, smoking, diabetes, and cancer.

FIG. 16.9 Evidence of contrast outside bowel lumen consistent with anastomotic leak (red arrow) and concurrent pneumoperitoneum.
attributed to moist peristomal skin. Cost-effective treatment includes over-the-counter antifungal creams, with allylamines reserved for patients in whom the initial treatment fails. Powders to dry the peristomal skin before placement of the stoma appliance should be used. Peristomal folliculitis can also occur owing to trauma to hair follicles from stoma adhesive removal or shaving of the peristomal skin. *S. aureus* is the most common species of bacteria seen in peristomal folliculitis. The reddened skin with pustules can be difficult to distinguish from candidiasis, and frequently these patients are first treated for candidiasis. Cleansing with antibacterial soap and applying an antibacterial powder treats the folliculitis.

**Retraction**

The overall incidence of stomal retraction ranges from 1.4% to 9%. Stomal retraction is defined as a stoma that is more than 0.5 cm below the skin surface within 6 weeks of operation, typically as a result of tension on the stoma. The most common risk factors are obesity, shortened mesentery, and initial stomal height less than 10 mm. Acute retraction can result in dehiscence of the mucocutaneous junction and intraperitoneal contamination. Retraction is caused by excess tension placed on the matured segment of bowel, which is typically the result of inadequate mobilization (Fig. 16.12). Accordingly, attempts at local revision may not succeed because the underlying cause of the tension cannot be fully addressed through a peristomal incision. Laparotomy is usually needed to gain more length and to revise the stoma in a tension-free manner.

Several preventive measures can be undertaken at the initial operation for colonic stomal retractions. For left-sided stomas, dividing the sigmoidal vessels may not be sufficient. The stoma will be tethered by the inferior mesenteric artery (IMA) pedicle.
Ligating the IMA proximal to the origin of the left colic artery and dividing the inferior mesenteric vein (IMV) will provide significant additional strength. Using a segment of bowel that is edematous or inflamed is also discouraged because the associated mesentery will lack pliability and is often foreshortened. Other useful measures include the complete dissection of the colon from its lateral peritoneal attachments or mobilization of the splenic flexure.43,50

**Prolapse**

The incidence of stomal prolapse is variable and ranges from 2% to 22%. Prolapse is often a late complication of stomal formation (Fig. 16.13). Elevation in abdominal pressures (i.e., straining) and redundancy of bowel segments are proposed causes.51 Direct fixation of the bowel at the fascial level as a preventive measure has been suggested. However, fixation of the bowel or mesentery remains controversial. Although some authors have found this maneuver to be useful, others have reported that it has no bearing on the subsequent occurrence of prolapse.52

Stomal prolapse can be treated with a combination of local conservative measures and surgical revision. Prolapse of a stoma, although disconcerting to the patient, is rarely a surgical emergency. Often, the function of the ostomy is preserved. Reduction of the prolapsed stoma can be achieved with gentle manual pressure. If bowel edema and engorgement are present, topical application of table sugar or hyaluronidase injection can be used for osmotic therapy and reduction of edema. Larger and specially fitting stomal appliances can be used to maintain an acceptable seal and function. Surgical correction of stomal prolapse can often be performed through a local peristomal incision.

**Parastomal Hernia**

Parastomal hernia is a type of incisional hernia that forms in relation to the creation of an abdominal stoma. These hernias are uncommon in the early postoperative period (0%–3%),53 but the incidence of parastomal hernia increases with time, ultimately ranging from 14.1% to 40% (Fig. 16.14).54 Risk factors that lead to the development of a parastomal hernia are similar to those of other abdominal wall hernias. These include respiratory comorbidities, diabetes, surgical procedures for malignancy, and end colostomy as significant risk factors for parastomal hernia development.

Surgical options for correcting a parastomal hernia are local primary repair, relocation, and repair with mesh. Local primary repair does not require a laparotomy, and dissection can be minimal. The fascial defect around the stoma is plicated, and the technical ease of this procedure is appealing. The recurrence rates range from 46% to 100%,55,56 limiting its clinical applicability. This approach should have a role only in patients in whom a larger complex surgical repair is considered high risk or when mesh repair is strongly undesirable.

Relocation of the stoma can be performed through a formal laparotomy or by means of a local peristomal incision. The rate of recurrence at the relocated site ranges from 24% to 40%.57 The recurrence rate at the new site should be expected to be at least as high as that after the initial stoma creation. A second repair with relocation is associated with an even higher expected chance of recurrence (71%).57 Relocating the stoma to the same side of the abdominal wall further increases the likelihood of a recurrence (80%–86%).55 Overall, the data are limited in comparing direct repair and relocation. In the short term, it seems that relocation offers a better outcome. However, with longer postoperative follow-up, the re-recurrence rates appear to be high, regardless of whether direct repair or relocation is performed. The success

![FIG. 16.11 Peristomal skin irritation and ulceration. (Courtesy Dr. Ricardo Mentz.)](image)

![FIG. 16.12 (A) Stomal retraction. (B) Stomal retraction with enterocutaneous fistulas. (Courtesy Dr. Ricardo Mentz.)](image)
use of mesh repair for other types of incisional hernias has naturally attracted attention to its use for parastomal hernia. Various techniques and modifications have been described, including the placement of the mesh in an inlay, in an overlay, in a sublay or retromuscular position, and in an intraperitoneal position. A review of the literature indicates that the recurrence rates for parastomal hernia with mesh repair range from 6.9% to 17.8%, which compares favorably to both direct repair and relocation.58

Strategies to prevent parastomal hernias include limiting the size of the trephination, directing the bowel through the rectus abdominis, and creating an extraperitoneal course. No clear consensus exists regarding the ideal location of trephination through the abdominal wall musculature. Studies have suggested that the course through the rectus abdominis is favorable. Others have found no correlation between the position of the stoma in relation to the rectus abdominis and the rates of parastomal hernia.59,60 The size of the trephination is also a matter of some debate. As a general guideline, an aperture of two fingerbreadths is an acceptable size. It is recommended to avoid adherence to strict sizes and to use an approach in which the smallest aperture is developed to a size that allows passage of the bowel without vascular compromise.

**Necrosis**

Vascular compromise to the stoma may be localized to the superficial aspect of the stoma or can extend deeper below the level of the fascia. Partial or superficial necrosis is more common, with an incidence of 2% to 20%. More serious complete or deep necrosis can occur in 0.37% to 3% of patients53,49 (Fig. 16.15). When creating a stoma, the surgeon must ensure that there is no vascular compromise by mobilizing a segment of bowel that reaches the skin adequately while at the same time maintaining an adequate vascular supply in the process. Assessment for possible ischemia and prevention of ischemia should take place well before the patient leaves the operating room. Any question of compromised viability of the stoma must be addressed and revised at the initial operation.

Excessive trimming of the epiploic fat and the mesentery should be avoided. In general, an end ileostomy will maintain adequate blood supply with dissection of the mesentery for up to 5 cm from the distal end. Collateral flow is maintained through the submucosa of the terminal ileum. Colonic arterial flow is maintained through the marginal artery; at least a 1-cm portion of the colonic mesentery adjacent to the bowel wall should be preserved to maintain patency of the marginal artery. Confirmation of pulsatile flow by digital palpation of the preserved colonic mesentery is recommended and generally ensures viability of the colostomy. Alternatively, surgeons may use intraoperative Doppler to evaluate adequate blood supply to the stoma.

Even with adequate mobilization and a viable-appearing bowel segment, a stoma may appear “dusky” as it is passed through the abdominal trephination owing to venous congestion. As peristomal edema recedes postoperatively, the venous congestion often improves. If venous outflow obstruction is suspected intraoperatively, options include careful enlargement of the trephination, judicious trimming of excess mesenteric fat to reduce bulk, or both.

Obese patients may present a specific challenge during stoma formation. In obese patients, a thicker subcutaneous adipose layer will necessitate greater dissection of the mesentery and sacrifice of blood supply to bring up an end stoma. It is generally recommended to place the stoma higher on the abdomen in obese patients because the upper quadrants of the abdomen often have a less prominent adipose layer. Bowel with compromised blood supply, as evidenced by dark, purple, or grayish mucosa, is quite evident once the bowel has been opened and the stoma is being matured. However, this stage of the operation

FIG. 16.13 Stomal prolapse with evisceration of bowel through stomal site. (Courtesy Dr. Ricardo Mentz.)

FIG. 16.14 Massive parastomal hernia with large bowel evisceration through fascial defect. (Courtesy Dr. Ricardo Mentz.)

FIG. 16.15 Stomal necrosis.
is often performed at the very end of the case. If possible, preparing the segment of bowel for the proposed stoma should be done early in the operation. This allows any demarcation to present itself well in advance and to become clearly visible on the serosal surface.\textsuperscript{61}

In the postoperative period, edema is common, and as a result, venous congestion may occur. A flashlight can be used to directly transilluminate the stoma quickly and easily. Touching the flashlight onto a viable stoma will make it illuminate to a healthy red hue. Transillumination will occur even in a congested stoma, if such stoma is viable. Ischemia, if identified, must be fully evaluated, and its extent must be assessed. Superficial ischemia of only several millimeters, and confined to the portion above the skin level, may lead to mucocutaneous separation or abscess. Such problems can be treated locally. However, even relatively minor ischemic changes in the stoma may well result in future poor stomal function and pouching difficulties with significant patient dissatisfaction.

More extensive ischemia can be visualized with the use of a phlebotomy test tube. The well-lubricated glass tube is gently inserted into the stoma, and a penlight is used for illumination. Failure of transillumination and evidence of necrosis below the fascial level requires urgent laparotomy and revision. When the degree of ischemia or necrosis extends to the subcutaneous level but remains above the fascia, one can expect stomal stenosis. The patient may recover without the need for urgent or emergent reoperation, but stomal revision will likely be required at a later time. Another diagnostic alternative includes direct visualization with a pediatric rigid proctoscope or a flexible endoscope. Use of a needle to scratch the mucosa to assess for bleeding is a further option to distinguish ischemia from congestion.\textsuperscript{43,50}

### Mucocutaneous Separation

The incidence of mucocutaneous separation ranges widely from 4\% to 25.3\%. Occurrence is usually in the early postoperative period and can be attributed to an improperly matured stoma or excessive traction. Care must be taken to suture full-thickness stoma to the skin to prevent separation of the suture line. Treatment of mucocutaneous separation is by packing the separated area with a filling paste or powder and covering the separated area with the stoma appliance.\textsuperscript{43}

### Fistulas

Intestinal or urostomy fistulas are an uncommon but serious complication of pelvic exenteration. In an initial study from MD Anderson Cancer Center by Miller and colleagues,\textsuperscript{62} the authors found that the rate of intestinal fistulas was 16\% when no pelvic floor reconstruction was used. However, this rate decreased to 4.5\% when peritoneum or sigmoid lid, with or without omentum, was used by the same group. In a more recent article, Westin and colleagues\textsuperscript{3} from the same institution reported that the rate of intestinal fistulas was 8.8\%. In the study by Miller and colleagues,\textsuperscript{62} the authors found that the most common type of fistula was small bowel to pelvis (36\%), followed by complex fistulas in 26\% of patients. The overall mortality rate from fistula formation has been reported to be as high as 36\%.\textsuperscript{62}

A high-output fistula is characterized as having an output of more than 500 mL per 24 hours; a moderate-output fistula, between 200 and 500 mL per 24 hours; and a low-output fistula, less than 200 mL per 24 hours. Another classification used to categorize fistulas is based on the site of origin: type I (abdominal, esophageal, gastroduodenal), type II (small bowel), type III (large bowel), and type IV (enteroatmospheric, regardless of origin). The most common reason for fistula formation after pelvic exenteration is an anastomotic leak or inadvertent injury to the small bowel during dissection.\textsuperscript{63}

### Signs and Symptoms

The most common types of presenting symptoms noted in patients with fistulas after pelvic exenteration in the study by Miller and colleagues\textsuperscript{62} were abnormal drainage from incision or neovagina, visible fistula on physical examination, fever, nausea and vomiting, or necrosis of the neovagina. The patient may exhibit abdominal discomfort, distention, tenderness, a low-grade fever, or signs of abdominal sepsis. Other signs may be dependent on the location of the fistula and organs affected.

### Evaluation

The definitive diagnosis of a fistula is made by showing the abnormal connection between the bowel and skin or of bowel to bowel or other areas within the abdominal cavity. CT is the preferred initial study for patients suspected of having a fistula. It may demonstrate the location of the fistula and also associated intraabdominal abscess, areas of fluid collection, and areas of intestinal obstruction. A contrast study such as a small bowel follow-through or contrast enema, depending on the suspected level of the fistula, may demonstrate the site of a suspected fistula. Alternatively, for enterocutaneous fistulas that have a well-defined cutaneous opening, in the absence of sepsis, a fistulogram can document continuity of the intestine and enable evaluation for distal obstruction. A fistulogram is obtained by injecting a water-soluble contrast agent into the opening of the fistula to identify the fistulous tract.\textsuperscript{64,65} (Fig. 16.16). Subsequently, a guidewire may be used to place an angiographic catheter to further define any associated pockets or cavities. Small fistulas may not be visible with routine imaging. In such cases, a simple method to determine whether or not an enteric fistula is indeed present is by the administration of a dye such as indigo carmine or methylene blue. The appearance of blue staining in the wound drainage, urine, or feces or from the vagina may confirm that an enteric fistula is present.

### Treatment

Closure rates without operative intervention in the era of advanced wound care and parenteral nutrition vary considerably, ranging from 19\% to 92\%, with most studies demonstrating closure rates in the 20\% to 30\% range.\textsuperscript{63} It is estimated that 90\% of spontaneous closures occur in the first month, with an additional 10\% of fistulas closing in the second month, and none closing spontaneously after 2 months. Conservative management is advisable only when signs of infection or sepsis are absent. Because delayed healing and weight loss are prevalent among such patients, improvement of nutritional status by total parenteral nutrition is important for successful treatment. In summary, conservative treatment should include all of the following: rehydration, administration of antibiotics, correction of anemia, electrolyte repletion, drainage of associated abscess, nutritional support, control of fistula drainage, and skin protection.

The indications for surgery are as follows: lateral duodenal or ligament of Treitz fistula, ileal fistula, high-output fistula, or any fistula associated with diseased bowel, distal obstruction, or eversion of the mucosa. In performing a surgical repair, it is important to preserve as much functional bowel as possible to
prevent short bowel syndrome. It is also important to perform the procedure without posing a high risk of injury to the adjacent normal bowel.

The surgical approach should be as follows:

**Incision:** The abdomen should be entered through a fresh incision to avoid injury to underlying bowel that may be adherent to the anterior abdominal wall. If the enterocutaneous fistula is in the midline, an effort should be made to enter the abdomen either above or below the fistula tract.

**Evaluation of bowel integrity:** Once the abdomen has been entered, the surgeon should inspect the bowel from the ligament of Treitz to the rectum. Then the fistulous tract is dissected free from the surrounding tissue. The segment of bowel that is involved should be removed, with subsequent anastomosis of the normal-appearing bowel. If bowel resection and anastomosis are not feasible, then exteriorization of the bowel via ileostomy or colostomy should be performed. A wound VAC (vacuum-assisted closure) may be placed over the site where the fistula had drained before repair in order to promote granulation tissue formation. Alternatively, the use of fibrin glue injected through a catheter endoscopically has been shown to have a success rate of 87.5% for low-output fistulas and 55% for high-output fistulas.

**Pelvic Reconstruction Complications**

Several approaches to vaginal reconstruction have been used, including split-thickness skin grafts, gracilis myocutaneous thigh flaps, and rectus abdominis myocutaneous (RAM) flaps, either vertically (VRAM) or transversely (TRAM) oriented. After pelvic exenteration, patients who undergo pelvic floor and vaginal reconstruction report less psychosocial dissatisfaction and improved body image and sexual function and have better primary healing with fewer postoperative complications. In the study by Westin and colleagues, the authors reported a rate of flap complications of 15.6%. The focus of this section is complications related to the two types of pelvic floor reconstructions most commonly performed after pelvic exenteration: the RAM flap and the bilateral gracilis flap. The details of the management of complications of pelvic reconstruction are addressed in Chapter 20.

**Modified Rectus Abdominis Flap**

Rectus abdominis flaps have the advantage of using the primary incision, require only one donor site, and have a vascular pedicle with a large arc of rotation that is highly reliable. The modified vertical rectus abdominis flap provides a cosmetically superior result compared with the gracilis myocutaneous flap, leaving a single midline scar, and the VRAM flap does not interfere with concomitant colostomy or urinary conduit placement.

In a study by Berger and colleagues, the authors reported on the MD Anderson Cancer Center experience with the modified vertical rectus abdominis flap. In that report, 46 patients were identified who underwent exenteration with modified vertical rectus abdominis flap vaginal reconstruction. A risk factor for poor healing, including obesity, diabetes, smoking, prior radiation, previous abdominal surgical procedure, or poor nutritional status, was present in 38 (82.6%) patients, and 24 (52.2%) had two or more risk factors.

Superficial separation of the anterior abdominal wall wound was the most common complication, affecting 22 patients (47.8%); 21 of these separations occurred within 60 days of

![FIG. 16.16](A) Computed tomography scan of the abdomen and pelvis (sagittal view). Fistulous tract communication between small bowel and anterior abdominal wall incision abscess (arrow). (B) Fistulogram. Enterocutaneous fistula cannulized to demonstrate sinus tract from dilated jejunal loop to anterior abdominal wall.
operation. Flap complications occurred in a total of nine patients (19.6%). Six of these complications were considered short-term and three were long-term complications. Two patients had superficial flap necrosis that was managed with office debridement. Three patients had a superficial separation of the flap, requiring wound care. The one patient with complete flap necrosis was noted to have venous congestion of the modified vertical rectus abdominis flap in the immediate postoperative period. No individual risk factor was significantly associated with modified vertical rectus abdominis flap–related morbidity; however, obesity, prior radiation, and prior abdominal incision were present in nearly all the patients with flap complications (Table 16.2).

**Gracilis Myocutaneous Flap**

The usefulness of the gracilis flap in large pelvic and perineal defects is considered limited because of the smaller mass of the muscle, the technical difficulty designing the skin island, and the high rate of associated complications.

In a study by Soper and colleagues, the authors compared gracilis (n = 44) and RAM (n = 32) flap reconstruction. The authors found that although there were significant increases in the number of overall and pelvic flap–specific complications in the gracilis myocutaneous group compared with the rectus abdominis group (overall, 35 vs. 15, respectively), the proportion of patients developing these complications was not significantly different between the two groups. However, the combined incidence of any degree of flap loss (>10%) was increased in the gracilis flap group: 30% versus 6%, respectively (P < .02).

There are several reasons for the increased risk of flap loss when a gracilis myocutaneous flap is used. Locating the skin island supplied by perforators through the gracilis muscle can be challenging in an obese patient with sagging inner thigh skin. The smaller primary and secondary vascular pedicles might also be more vulnerable to compression as the gracilis flap is rotated through the subfascial tunnel under the pubic ramus, when compared with the larger deep inferior epigastric vascular pedicle supplying the rectus abdominis flap, which rotates medially into the pelvis without directly crossing any bony structures.

The choice of flap reconstruction after pelvic exenteration remains a topic for discussion with the patient, and the ultimate decision regarding the type of reconstruction should be based on patient selection, surgeon experience, and availability of a multidisciplinary team that will ultimately optimize patient recovery and functional capacity in the postoperative period.

**References**

17. Deleted in review.
Chapter 16 Complications of Pelvic Exenteration


The field of gynecologic oncology has undergone an evolution, mirroring the growing knowledge of the pathophysiology of gynecologic malignancies and the introduction of new treatment modalities and innovative techniques. The introduction of targeted therapies, precision medicine, genomic profiling, genetic testing, and checkpoint blockade immune therapies is advancing the field rapidly and adding promising new medical treatment options for women with gynecologic cancers.

Today, gynecologic oncologists are often operating at the console of a robotic surgical system remote from the patient and performing complex surgical procedures. The sentinel lymph node algorithm is finding its way into the surgical treatment of endometrial and cervical cancers, and cytoreductive surgery is expanding the frontiers in the treatment of women with advanced-stage ovarian cancer, targeting upper abdominal disease more effectively. The introduction of surgical site reduction bundles and new Enhanced Recovery After Surgery (ERAS) pathways is improving the quality of surgical care further.

Today’s gynecologic oncologist should be able to perform more than a radical hysterectomy, bilateral salpingo-oophorectomy, and omentectomy. He or she must be an accomplished surgeon with a mastery of pelvic procedures including the associated urologic, intestinal, and upper abdominal procedures and their complications. Such a mastery is necessary to optimally treat women with gynecologic malignancies.

This chapter focuses on small and large bowel resection and anastomosis in the setting of gynecologic cancer surgery. Operation on the intestinal tract is frequently necessary in patients with gynecologic cancers. Indications include the resection of disease and also the management of bowel obstructions and other disease- or treatment-related complications. Mastering the technique of intestinal surgery is important because complications from intestinal surgery are devastating and unforgiving. Anastomotic leak after a small bowel or colon procedure can be a devastating problem. Understanding the anatomy with the development of the correct surgical planes, maintaining the blood supply and the innervation, achieving meticulous hemostasis, and minimizing tissue trauma form the basis for safe and successful intestinal surgery.

Regional Vascular Anatomy of the Small Bowel and Large Bowel

The celiac artery and superior mesenteric artery (SMA) are the two principal visceral vessels supplying the liver, the biliary tree, the spleen and pancreas, the omentum, and the remainder of the gastrointestinal tract, except for the esophagus, the rectum, and the colon distally to the midtransverse colon (Fig. 17.1). The inferior mesenteric artery (IMA) supplies the splenic flexure of the colon, the descending colon, the sigmoid colon, and the rectum (Fig. 17.2). The rectum also receives blood supply from the internal iliac arteries. The celiac axis is the largest branch of the aorta at the level of the 12th thoracic vertebra and arises at a right angle from the anterior aspect of the abdominal aorta. The SMA arises only 1 to 2 cm below the origin of the celiac artery. The celiac artery gives rise to the common hepatic artery, the splenic artery, and the left gastric artery (Fig. 17.3). The common hepatic artery gives rise to the gastroduodenal artery and the proper hepatic artery, which branches into right, middle, and left hepatic arteries. Sometimes the right hepatic artery is a branch of the SMA. The splenic artery runs along the superior aspect of the pancreas and gives rise to the dorsal pancreatic artery, which supplies the body of the pancreas. The dorsal pancreatic artery anastomoses with the superior mesenteric circulation via the pancreaticoduodenal artery, a major communication between the celiac and the superior mesenteric circulation. Other branches of the splenic artery penetrate though the body of the pancreas, distally, short gastric arteries (the number varies from 2 to 15) arise from the splenic artery. The gastropiploic artery usually arises from the splenic artery late just before the latter enters the splenic hilum. The left gastropiploic artery anastomoses with the right gastroepiploic artery, a branch of the gastroduodenal artery. The SMA provides the entire blood supply to the jejunum and ileum. It arises from the aorta at the level of the first lumbar vertebra and measures approximately 1 cm in diameter. It lies behind the neck of the pancreas; it then passes over the uncinate process, anterior to the third part of the duodenum, before entering the root of the small bowel mesentery. Constant branches of the SMA include the inferior pancreaticoduodenal, the middle colic, the right colic, the ileocolic, and the intestinal arteries.
inferior pancreaticoduodenal artery is the first branch given off and supplies the retroperitoneal duodenum. The middle colic artery is the second branch of the SMA (Fig. 17.4). This vessel is an important landmark in the management of superior mesenteric arterial occlusive problems. The remaining small intestine is supplied by the jejunoileal arteries. They arise from the left side of the SMA after it enters the mesentery. These consist of 12 to 20 branches. These branches extend into the mesentery, where they form arcades. From these arcades, the vasa recta arise and pass to the mesenteric border of the bowel without anastomosing with one another. The avascular spaces are called the windows of Deaver. The vasa recta continue to form the subserosal plexus. These are sufficient to supply 6 to 8 cm of small intestine if the adjacent vasa recta have been occluded or ligated. The SMA also gives rise to the middle colic, right colic, and ileocolic arteries, arising from the right side of the SMA, which supply the cecum, ascending colon, and transverse colon, respectively. The space of Treves is an avascular space between the SMA and ileocolic artery, which may result in an inconsistent blood supply to the terminal ileum. Venous drainage of the small intestine is composed of direct tributaries that correspond to the branches of the SMA to form the superior mesenteric vein. This joins the splenic vein to form the portal vein.

The IMA arises from the left aspect of the aorta, usually at the level of L3, averaging 3 to 4 cm in length before branching (Fig. 17.5). The IMA is 5 mm in diameter; it gives rise to the left colic branch, three or four sigmoidal branches, and the superior rectal (also known as superior hemorrhoidal) artery.

Important collateral pathways of the mesenteric circulation include the communicating network between the SMA and IMA. One important communication between the SMA and the IMA is the arc of Riolan, also known as the meandering mesenteric artery (see Fig. 17.4). This vessel connects the ascending branch of the left colic artery with a branch from the SMA just proximal to the origin of the middle colic artery. The meandering mesenteric artery is not to be confused with the marginal artery of...
FIG. 17.2 Inferior Mesenteric Artery. Ventral view; transverse colon reflected cranially. The unpaired inferior mesenteric artery branches off the abdominal aorta approximately 5 cm above its bifurcation and turns to the left side. With the exception of a short terminal section, the inferior mesenteric artery descends into the retroperitoneal space to supply the descending colon and the upper rectum. Branches of the inferior mesenteric artery, Left colic artery: ascends along the descending colon and anastomoses via the left colic artery with the middle colic artery (Riolan anastomosis). Sigmoid arteries: several branches to the sigmoid colon. Superior rectal artery: supplies rectum and the rectal cavernous bodies in the submucosa (corpus cavernosum of rectum), which are a part of the continence mechanism. (From Paulsen F, Waschke J. Sobotta Atlas of Human Anatomy. 15th ed. Munich: Elsevier, Urban & Fischer; 2011.)

Drummond, which is located more peripherally in the mesentery. The marginal artery of Drummond connects the left branch of the middle colic artery (from the SMA) with the ascending branch of the left colic artery (from the IMA). This is a series of arcades along the mesenteric border of the entire colon beginning at the ileocolic artery and running to the sigmoid arteries; thus, it connects the vasculature of the SMA and IMA. The marginal artery gives rise to the vasa recta, which enter the colon wall and form intramural anastomoses. These intramural anastomoses are not as extensive as in the small bowel, and they can supply only 2 to 3 cm of colon compared with the 6 to 8 cm in the small intestine. In approximately 5% of patients, the marginal artery is deficient in one or more of the following areas: the last 6 to 8 cm of the terminal ileum, between the ileocolic and right colic arteries, between the middle and left colic arteries (termed the avascular area of Riolan), and between the superior rectal and last sigmoid arteries. The surgeon should be aware of these deficiencies because they may lead to compromise of intestinal integrity. Identification of the major arteries before resection of a portion of the colon can help avoid the unfavorable situation of unrecognized vascular insufficiency.

The middle and inferior rectal (hemorrhoidal) branches of the internal iliac arteries anastomose with the superior rectal (hemorrhoidal) branch of the IMA (Fig. 17.6). This circuit

**FIG. 17.4 Course of the Superior Mesenteric Artery and Vein.** Ventral view; after opening of the mesentery with the transverse colon reflected cranially. Within the mesentery, the superior mesenteric artery gives rise to the following branches: jejunal arteries and ileal arteries to the left side and middle colic artery, right colic artery, and ileocolic artery to the right side. All arteries form arcades at different levels of their divisions. This allows mobility of the intestinal loops. At the left colic flexure, the middle colic artery forms a functionally important anastomosis (Riolan anastomosis) with the left colic artery from the inferior mesenteric artery. This facilitates the formation of collateral circulations in the case of occlusion of one of the arteries. The anastomosis between the two arteries in one of the arcades close to the intestines is occasionally referred to as Drummond anastomosis. In the clinical jargon, all anastomoses in the area of the left colic flexure are summarized as Riolan anastomosis. The venous branches correspond to the arteries. (From Paulsen F, Waschke J. Sobotta Atlas of Human Anatomy. 15th ed. Munich: Elsevier, Urban & Fischer; 2011.)
provides an important collateral circulation to the distal colon and rectum. The collateral mesenteric communications are important in the setting of occlusive disease. An occlusion of the IMA is compensated for by the SMA and the iliac arteries. An SMA occlusion is compensated for by the collateral circulation from the celiac artery via the pancreaticoduodenal arcade and the meandering mesenteric artery and the marginal artery of Drummond from the IMA.

The venous drainage of the colon follows the course of the arterial system and is composed of the superior mesenteric vein and the inferior mesenteric vein (IMV) (see Figs. 17.4 and Fig. 17.5). The IMV empties into the splenic vein, which then joins the superior mesenteric vein to form the portal vein. The portal vein ascends to the liver behind the bile duct and hepatic artery at the free edge of the lesser omentum. At the porta hepatis, the portal vein divides into the left and right branches, which eventually empty into the hepatic sinusoids. The portal system does have several anastomoses with the systemic venous system, which can compensate for obstructed portal venous return.

The lymphatic system of the colon also follows the arterial supply previously described. Intramural lymphatic channels drain into extramural lymph vessels, which empty into the colonic lymph nodes.

**Anatomy of the Small Intestine**

The small intestine extends from the pylorus to the cecum and consists of the duodenum, jejunum, and ileum. This chapter focuses on the last two of these components of the small intestine.
The absorption of water, electrolytes, and nutrients is a major function of the small intestine (Table 17.1). In addition, the small intestine contributes to the immune system and endocrine system. Together, the jejunum and ileum measure approximately 6 to 7 m in length, with the jejunum comprising the proximal 40% and the ileum accounting for the distal 60%. Despite the fact that there is no sharp morphologic distinction between the jejunum and ileum, there are certain characteristics that help distinguish between the two:

1. The jejunum has a thicker wall owing to the fact that the circular folds, or plicae circulares, are larger and well developed in the proximal end of the small bowel; these folds are small in the superior part of the ileum and absent in the terminal ileum.

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Site of Absorption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple sugars</td>
<td>Entire small bowel</td>
</tr>
<tr>
<td>Amino acids</td>
<td>Jejunum</td>
</tr>
<tr>
<td>Fatty acids</td>
<td>Entire small bowel</td>
</tr>
<tr>
<td>Vitamin B(_{12})</td>
<td>Terminal 100 cm of ileum</td>
</tr>
<tr>
<td>Bile salts</td>
<td>Terminal 100 cm of ileum</td>
</tr>
<tr>
<td>Water-soluble vitamins</td>
<td>Entire small bowel</td>
</tr>
<tr>
<td>Fat-soluble vitamins</td>
<td>Jejunum and ileum</td>
</tr>
<tr>
<td>Water</td>
<td>Ileum and right colon</td>
</tr>
</tbody>
</table>

**FIG. 17.6 Rectal Arteries.** Dorsal view. Rectum and anal canal are supplied by three arteries: superior rectal artery (unpaired), from the inferior mesenteric artery; middle rectal artery (paired), from the internal iliac artery above the pelvic floor (levator ani); inferior rectal artery (paired), from the internal pudendal artery beneath the pelvic floor. The border between the corresponding arterial supply from the inferior mesenteric artery and the internal iliac artery is located at the pectinate line, where numerous anastomoses between these arteries exist. The superior rectal artery is the last branch of the inferior mesenteric artery and provides a branch for the anastomosis with the sigmoid arteries. From this point onward (clinical term, Sudeck point [*]), the superior rectal artery (clinical term, superior hemorrhoidal artery) is considered a terminal artery. The corpus cavernosum of rectum is primarily supplied by the superior rectal artery. Therefore, bleeding of hemorrhoids, which represent dilated rectal cavernous bodies, is arterial bleeding, as shown by the bright red color. (From Paulsen F, Waschke J. Sobotta Atlas of Human Anatomy. 15th ed. Munich: Elsevier, Urban & Fischer; 2011.)
2. The jejunal mesentery contains less fat than that of the ileum, and the arterial arcades are easier to visualize than in the ileum.

3. The jejunal mesentery contains less fat than that of the ileum, and the arterial arcades are easier to visualize than in the ileum.

4. The jejunal mesentery contains less fat than that of the ileum, and the arterial arcades are easier to visualize than in the ileum.

Anatomy of the Large Intestine

The large intestine is approximately 1.5 m in length, beginning at the cecum and ending with the anus in the perineum.

The large bowel is characterized by full-thickness infoldings of the bowel wall, called haustra (Fig. 17.7). These infoldings correspond to transverse folds in the bowel lumen called plicae semilunares. The large bowel has three thickened bands of longitudinal muscle that run its length from the appendix to the rectum called taeniae coli (taenia omentalis, taenia libera, and taenia mesocolica). Contraction of the taeniae causes the haustra to become more prominent. The large bowel has small pouches of peritoneum filled with fat called appendices epiploicae that are most prominent on the descending and sigmoid colon.

The cecum is the most proximal portion of the large intestine (Fig. 17.8). It is a blind pouch that is 5 to 7 cm in length and projects caudal to the ileocecal junction in the right iliac fossa of the right lower quadrant. Usually, the cecum is entirely enveloped by peritoneum but does not have a mesentery. It is the widest part of the large intestine but also has the thinnest wall; thus, it is at highest risk for perforation in cases of large bowel obstruction. The appendix arises 2 to 3 cm inferior to the ileocecal junction. The appendix has its own short mesentery called the mesoappendix, which connects it to the inferior part of the mesentery of the ileum. The appendiceal artery is a branch off the ileocolic artery and runs in the mesoappendix. The ileum leads into the cecum and is separated by the ileocecal valve. Its function is to limit the reflux of colonic contents into the ileum.

Approximately 2 L of fluid enters the colon daily through the ileocecal valve.

The ascending colon measures approximately 15 to 20 cm long and runs from the ileocecal valve to the hepatic flexure. It ascends as a retroperitoneal structure covered by peritoneum only on its anterior and lateral surfaces. It lies anterior to the quadratus lumborum, psoas, and transversus abdominis muscles; inferior pole of the right kidney; and descending portion of the duodenum. Lateral to the ascending colon is the white line of Toldt, which represents the fusion of the colonic mesentery with the parietal peritoneum. There may be congenital adhesions between the anterior aspect of the ascending colon and the right abdominal wall (Jackson membrane). The hepatic flexure may have several attachments to the liver and gallbladder. The ascending colon and hepatic flexure are supplied by the ileocolic and right colic arteries, and the venous drainage is through the ileocolic and right colic veins, which drain into the superior mesenteric vein. The lymphatic drainage of the ascending colon is via the paracolic and epiploic lymph nodes, which empty into the superior mesenteric lymph nodes.

The transverse colon is the portion of large bowel that lies between the hepatic and splenic flexures. It is the longest portion of the large bowel and usually measures 30 to 60 cm in length. Occasionally, a redundant transverse colon will reach into the pelvis. Unlike the ascending and descending colon, the transverse colon has its own mesentery, which is longest in the center, and is therefore considered an intraperitoneal structure. The root of the mesentery of the transverse colon covers the descending part of the duodenum, the pancreas, and a portion of the left kidney. At the hepatic and splenic flexures, the mesentery is very short and may place the transverse colon in contact with the duodenum and the head of the pancreas, which may be injured during mobilization of the hepatic flexure. The splenic flexure is connected to the diaphragm by the phrenocolic ligament and to the spleen by the lienocolic ligament. The transverse colon is attached to the greater curvature of the stomach.
by the cephalic portion of the greater omentum, which is also referred to as the *gastrocolic ligament*.

The descending colon is approximately 20 to 25 cm in length; it begins at the splenic flexure and ends at the pelvic brim with the start of the sigmoid colon, which is demarcated by its intraperitoneal mesentery. The proximal part of the descending colon is attached to the peritoneum overlying the left kidney by the phrenicocolic ligament. Similar to the ascending colon, the descending colon is a retroperitoneal structure that is covered by peritoneum only on its anterior and lateral surfaces. Lateral to the descending colon is the white line of Toldt, which demarcates the correct plane to enter the retroperitoneal space to mobilize the descending colon.

The sigmoid colon begins at the pelvic brim, curves inferiorly along the left pelvic side wall over the bifurcation of the left common iliac artery, and finally runs in the midline. It is usually 45 cm long, but variations in length are very common. The taeniae coli are wider than in the rest of the colon. The sigmoid mesocolon begins at the pelvic brim and becomes longer to the midpoint of the sigmoid colon and then decreases in size as it travels inferiorly. Thus the sigmoid colon is significantly longer than its mesentery.

The sigmoid colon becomes the rectum in front of the sacrum at the level at which the sigmoid colon mesentery ends and the appendices epiploicae disappear. The taeniae coli become more diffuse around the rectum and form a complete outer layer of longitudinal muscle. The longitudinal muscles merge with the perineal body and with muscles of the external sphincter. The rectum is 15 to 18 cm in length. Proximally it is of similar diameter as the sigmoid colon, but more distally it widens to the infraperitoneal ampulla, which is capable of significant distention. The upper third of the rectum is covered by peritoneum anteriorly and laterally, the middle third is covered only anteriorly, and the lower third is without peritoneal covering. The peritoneum is tented forward to the upper vagina to form the rectouterine pouch of Douglas. The rectum passes inferiorly through a ligamentous gate formed by the left and right ligamentum sacrouterinum and travels posterior to the vagina. This surgical plane between the posterior vagina and the rectum is an important landmark during surgical procedures for gynecologic cancer because here the retroperitoneum can be entered below the peritoneal reflection and the perirectal fat and the anterior rectum can be developed in preparation for the resection.

**Surgical Techniques**

**General Principles of Intestinal Surgery**

Avoiding tissue trauma, gaining adequate exposure, and using knowledge of anatomy are essential in the performance of any surgical procedure, and especially with intestinal surgery. Selection of instruments, positioning, suture material, and stapling techniques are important but not as essential as the manner in which the details are executed. In addition, there are several important principles of successful intestinal surgery:

1. Use healthy and well-vascularized bowel segments for anastomosis.
2. Make sure no tumor is incorporated in the anastomosis.
3. Maintain an adequate lumen.
4. Preserve adequate perfusion.
5. Create a tension-free anastomosis.
6. Ensure hemostasis.
7. Ensure a watertight anastomosis.
8. Preserve as much healthy bowel as possible.
9. Exclude proximal or distal bowel obstruction before resection and anastomosis.
10. Avoid or minimize spillage of intestinal contents.
11. Consider a diverting ostomy in the setting of infection, peritonitis, or radiation changes.

**Intestinal Anastomosis**

**Techniques of Bowel Anastomosis**

Intestinal anastomoses can be performed using one of two general techniques: hand-sewn or stapled. Although the introduction of intestinal staplers has simplified and accelerated the creation of a bowel anastomosis, there are times when the hand-sewn technique may be indicated or useful, and the surgeon should be familiar with both techniques. Independent of the technique used, there are several general principles that are necessary to ensure a successful anastomosis.

**Hand-Sewn Anastomoses**

Hand-sewn anastomosis can be divided into two categories: one-layer and two-layer anastomoses. Variations in technique exist, including interrupted versus continuous closure, and the selection of absorbable or permanent suture. The choice is primarily dependent on the surgeon's preference, and the mentioned sutures are only examples. The small intestine heals very rapidly, reaching maximal strength in approximately 14 to 21 days. Although parts of the colon have varying levels of strength (e.g., the sigmoid is twice as strong as the cecum), the rate of healing is similar in all parts. This rate of colonic healing is similar to the rapid rate of healing of the small intestine. In contrast, the rectum heals significantly more slowly.

The edges of the small bowel are inspected for adequate perfusion. The antimesenteric edge is farthest away from the blood supply and is at highest risk for underperfusion.

The traditional hand-sewn small bowel anastomosis is performed by using a one-layer or a two-layer inverting technique. The sequence of layer closure depends on the mobility of the portions of intestine to be anastomosed.

The bowel ends are approximated with bowel clamps and two stay sutures, incorporating the seromuscular layer, placed midway between the mesenteric and antimesenteric borders to aid in alignment. The two-layered anastomosis begins with a placement of a single row of imbricating (Lembert) sutures on the posterior wall through the seromuscular layer. Placing the sutures before they are tied is helpful. If present, the staple lines on the ends of the divided bowel are excised (Fig. 17.9), and the inner mucosal layer is then completely reapproximated by using a 3-0 delayed absorbable suture. This is accomplished by using a continuous running suture on the posterior mucosal edges and a Connell inverting suture on the anterior mucosal edge. The anastomosis is then completed by placing a row of imbricating (Lembert) sutures on the anterior wall, placing all the sutures before tying them.

The one-layer closure has the advantage of decreasing the time required to form the anastomosis and producing a wider lumen because less of the bowel edge is inverted. A running 4-0 suture (Vicryl, Monocryl, or silk) can be used as a single-layer suture. Here the mesenteric side should be approximated first. Full-thickness sutures should be placed 5 mm from the edge (out to in), and ideally 1 to 2 mm of mucosa (for hemostasis) should be incorporated on both ends before exiting 5 mm from the edge on the contralateral side (in to out). The knot is tight at the outside of the bowel (Fig. 17.10). After this first mesenteric suture is tied, the bowel can be closed in a running fashion with the aforementioned technique (full-thickness suture including 5-mm seromuscular layer and 1–2 mm of mucosa); the distance between each suture should not be more than 3 mm to ensure a watertight anastomosis (Fig. 17.11). The suture is run until the antimesenteric side is reached. The bowel is turned 180 degrees, and a second mesenteric suture is placed right next to the previous one and tied as described earlier; then the suture is run to the antimesenteric side, where both sutures are tied together. The anastomosis is inspected, and interrupted sutures can be placed if necessary to ensure a watertight anastomosis. Alternatively, a 4-0 double-armed (Monofilament, Vicryl, or silk) suture can be used. The suture is placed at the mesenteric side (out to in and in to out) in a similar fashion as described earlier. Instead of tying a knot,
TABLE 17.2 Dimensions of Commonly Available Staple Cartridges Used to Accommodate Different Tissue Thicknesses for Appropriate Tissue Management

<table>
<thead>
<tr>
<th>Color</th>
<th>Rows</th>
<th>Tissue Type</th>
<th>Open Staple Height</th>
<th>Closed Staple Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gray</td>
<td>6</td>
<td>Mesentery</td>
<td>2.0 mm</td>
<td>0.75 mm</td>
</tr>
<tr>
<td>White</td>
<td>6</td>
<td>Vascular</td>
<td>2.5 mm</td>
<td>1.0 mm</td>
</tr>
<tr>
<td>Blue</td>
<td>6</td>
<td>Standard</td>
<td>3.5 mm</td>
<td>1.5 mm</td>
</tr>
<tr>
<td>Gold</td>
<td>6</td>
<td>Standard/thick</td>
<td>3.8 mm</td>
<td>1.8 mm</td>
</tr>
<tr>
<td>Green</td>
<td>6</td>
<td>Thick</td>
<td>4.1 mm</td>
<td>2.0 mm</td>
</tr>
</tbody>
</table>


The stapled anastomosis greatly depends on the delicate handling and knowledge of the stapling device. Optimal stapling of any tissue requires an adequate tissue compression time (to decrease the fluid in the tissue) to allow elongation of the tissue being compressed, smooth firing of the instrument, and consistent staple line formation without tissue tearing and excessive tensile strength.

Advantages of the hand-sewn anastomosis may be greater strength, reduced risk of stricture, and more complete healing. Stapled anastomoses are especially useful in the setting of rectal resections, wherein the hand-sewn closure is complicated by the deep anatomy and limited exposure and space. The end-to-end anastomosis (EEA) stapler technique has allowed very low anastomoses to be performed that were previously thought to be extremely difficult with suture.

**Types of Bowel Anastomoses**

There are several methods to join two segments of intestine. Each procedure can be performed with either a hand-sewn or stapled method. All methods should adhere to the general principles of intestinal anastomosis described earlier.

**End-to-End Anastomosis**

The hand-sewn EEA can be performed by using an open or a closed technique. The closed technique is rarely used in modern-day surgery. The open technique requires placement of noncrushing bowel clamps immediately proximal and distal to the line of resection. Both bowel limbs are occluded to prevent spillage of bowel contents. The clamps are usually applied several centimeters away from the ends to be anastomosed to provide adequate room to manipulate the bowel edges. The mesentery beneath the area to be resected should be inspected to ensure that a dominant vascular pedicle is supplying the distal and proximal portions of the remaining small bowel. After carefully aligning the bowel to avoid any twisting of the bowel, the edges are approximated with a 3-0 silk stay suture placed at an antimesenteric border. When there is a disparity between the lumen size of the two segments to be reanastomosed, a longitudinal Cheile incision may be created on the antimesenteric surface of the smaller lumen. This will provide an increased diameter of lumen and will also allow a more even approximation of the two segments of bowel. The hand-sewn anastomosis can

**FIG. 17.11** Running 4-0 Monocryl suture from the mesenteric side toward the antimesenteric side of the small bowel (out-to-in and in-to-out).
Chapter 17 Small Bowel and Large Bowel Resection and Anastomosis

Then be performed by using a one- or two-layer closure as described earlier.

Alternatively, the circular EEA stapler is a safe and expedient technique for EEAs. After the intestine has been divided (Fig. 17.12), the anvil can be placed in one end of the intestine and secured with a purse-string suture of 2-0 polypropylene placed by hand or by using one of the automated purse-string application devices (Fig. 17.13). The hand-sewn purse-string suture allows for ideal placement of sutures and inspection of the bowel lumen (Fig. 17.14). (The hand-sewn purse-string suture should incorporate the full thickness of the bowel. Sutures should not be placed more 0.5 cm from the margin of the bowel. After the anvil is secured, the bowel is inspected and excess tissue (mesentery or epiploica) is carefully removed from the anastomotic site (Fig. 17.15). Otherwise, too much tissue will be incorporated into the anvil and obstruct the stapling mechanism of the EEA stapler. This can result in a defective anastomosis. The size of the EEA stapler must be carefully selected based on the diameter of bowel lumen. Employing an EEA stapler that is too large may injure bowel wall and result in ischemia and necrosis. The other limb of bowel should be closed with a linear stapler, and the EEA stapler is introduced through an enterotomy or colotomy made on the antimesenteric side several centimeters proximal to the linear staple line. The EEA trocar is advanced through the midportion of the linear staple line and mated to the anvil. The EEA stapler can be fired and removed. The enterotomy or colotomy can then be closed by using a thoracoabdominal (TA) stapler placed perpendicular to the long axis of the bowel.

FIG. 17.12 The staple line on the end of the divided sigmoid colon is excised.

FIG. 17.13 The anvil is placed in the lumen of the sigmoid colon.

FIG. 17.14 The hand-sewn purse-string suture allows for ideal placement of sutures and inspection of the bowel lumen.
End-to-Side Anastomosis

The end-to-side anastomosis would typically be used after an ileocecal resection or right hemicolectomy, in which ileum is joined to large bowel. It is useful when joining two portions of intestine with different luminal diameters and can be performed by using either a sutured or stapled technique. A stapled end-to-side anastomosis can also be performed using the circular EEA stapler. In this technique, the anvil is placed in the distal terminal ileum and secured with a purse-string suture as described earlier. The main EEA stapler instrument is introduced into the open end of the colon, and the trocar is advanced through the antimesenteric wall. The anvil is mated to the shaft of the main EEA instrument, and the stapler is closed and fired, creating a double row of circular staples and simultaneously excising an internal ring of tissue from each bowel limb to complete the anastomosis. This instrument is removed and inspected to confirm that two complete “doughnuts” of bowel wall have been excised, ensuring a full-thickness anastomosis. The open end of the colon is then closed off with a TA stapler. After an adequate lumen is confirmed, the mesenteric defect is closed.

In the hand-sewn technique, the narrow-caliber bowel end is aligned perpendicular to the larger caliber bowel in an end-to-side fashion and secured with stay sutures. Proximal and distal bowel clamps are recommended to minimize spillage of intestinal contents. An incision is created on the antimesenteric border of the large-caliber bowel segment (i.e., colon) that will accommodate the circumference of the smaller segment (i.e., terminal ileum). The anastomosis is completed using a one- or two-layered hand-sewn technique with 3-0 delayed absorbable or permanent monofilament suture as previously described.

Side-to-Side Functional End-to-End Anastomosis

A side-to-side functional EEA is commonly used to reestablish intestinal continuity after segmental resection (e.g., ileum to ileum, ileum to ascending colon).

The stapled technique of functional EEA, using both gastrointestinal anastomosis (GIA) and TA staplers, is as secure as the hand-sewn technique but probably faster and easier to perform for most surgeons (Fig. 17.16). Stay sutures are placed to delineate the common lumen of the two segments to be joined, the ends of which have been previously closed with the linear stapler. The two blind ends of intestine to be connected are again aligned side by side along their antimesenteric borders with stay sutures. The antimesenteric corners of the linear staple lines are trimmed, and one leg of the GIA stapler is introduced into each lumen. The stapler is then fired and the suture is inspected, the staple line is offset slightly to avoid intraluminal adhesion formation, and the remaining defect is closed with a TA staple (Fig. 17.17). In the hand-sewn technique of functional EEA, the two segments of bowel are aligned side by side between stay sutures placed 8 to 10 cm apart along the antimesenteric borders to form an isoperistaltic intestinal cul-de-sac. Parallel linear incisions are created in each bowel segment between the stay sutures, and these will form the anastomotic lumen. The two-layer closure technique is standard and starts with an outer posterior layer of interrupted seromuscular stitches of 3-0 silk. The inner posterior and anterior layers are reapproximated with a continuous, nonlocking stitch of 3-0 delayed absorbable suture. Finally, the outer anterior layer of interrupted seromuscular stitches completes the closure.

After any anastomosis, the new lumen should always be checked for adequacy by invaginating the two limbs of intestine between thumb and index finger. If deemed necessary, the mesenteric defect can be closed to prevent an internal herniation through the defect. Care should be taken not to injure any of the mesenteric vessels, which could compromise the blood supply to the anastomosis.

Small Bowel Resection

The specific technique of small bowel resection will vary according to the clinical situation, but in general, it can be broken down into five basic elements:

1. Identifying the portion of small bowel to be resected
2. Dividing the bowel
3. Dividing the mesentery
4. Performing the anastomosis
5. Closing the mesenteric defect

Before the bowel or mesentery is divided, the remaining intestinal tract should be carefully inspected for additional areas of disease, impending obstruction, or inadequate perfusion that would ultimately require surgical correction (Fig. 17.18). This ensures that the planned resection will accomplish its intended purpose and that the anastomosis will be technically feasible, well perfused, and viable. The segment of the small bowel to be removed should be clearly demarcated at the proximal and distal points, leaving approximately 5-cm segments of healthy bowel on either side to ensure an adequate margin of resection. Transillumination of the mesentery and palpation for an arterial pulse can be used to check the blood supply to the remaining
bowel. To prevent spillage of bowel contents directly into the abdominal cavity, warm moist lap packs can be used to isolate the specimen, and soft bowel clamps can be applied about 20 cm from the proximal and distal bowel end to avoid excess contamination.

Mesenterectomies are created through windows of Deaver at the corresponding proximal and distal points of resection. The small bowel is divided either between two applications of the linear GIA stapling device or between bowel clamps (Fig. 17.19). After the bowel is divided, the mesentery supplying the portion of bowel to be removed should be divided (Fig. 17.20). Whether a linear stapler or traditional clamps are used, transecting the bowel at an oblique angle in a fashion such that the greater portion is removed from the antimesenteric side ensures adequate vascular perfusion to the entire transected edge. The antimesenteric side of the bowel is the area farthest away from the mesenteric perfusion, and trimming the antimesenteric end obliquely allows for adequate perfusion. The knife, scissors, or cautery device should be used to score the bowel mesentery on each
side and delineate the V-shaped segment to be removed. The jejunal and/or ileal vessels are skeletonized and traditionally have been individually ligated with 3-0 silk or delayed absorbable ties; however, care must be taken not to injure the SMA or the middle colic artery, which can be injured at the base of the small bowel mesentery either directly or because of undue traction. Novel technology such as a ligating dividing stapler (LDS) or vessel sealer (LigaSure; Covidien, Mansfield, Massachusetts), which simultaneously transects and secures hemostasis, can be used to divide the mesentery. A side-to-side functional EEA using the GIA and TA staplers or hand-sewn end-to-end closure is then performed. Because of an unpredictable blood supply and increased tension on the anastomosis, the distal 8 to 10 cm of terminal ileum should not be incorporated into the anastomosis. If this is the case, the distal ileum should be included in the resection and the anastomosis performed to the cecum or ascending colon.

### Ileoceleal Resection

Tumor involvement of the ileocecal region or a bowel obstruction of the terminal ileum can mandate resection of the terminal ileum in conjunction with a portion of the ascending colon. The tumor-involved intestine is mobilized by incising the parietal peritoneum from the terminal ileum, around the cecum, and along the white line of Toldt up to the hepatic flexure. The hepatic flexure is freed to permit additional mobility of the ascending colon as it is separated from its attachments to the retroperitoneum by a combination of careful blunt and sharp dissection. Care has to be taken to not injure the duodenum during this process. The ileum is then mobilized by incising along the base of the small bowel mesentery toward the ligament of Treitz. The terminal ileum, ascending colon, and proximal transverse colon are reflected medially, taking care not to injure the right ureter, ovarian vessels, duodenum, and head of the pancreas. The extent of the resection can then be delineated and the ileum and ascending colon can be divided between proximal and distal Kocher clamps or by using two applications of the GIA stapling device. As previously mentioned, the distal 8 to 10 cm of ileum should be removed with the cecum, because this area can have an inconsistent blood supply, which may result in a poorly vascularized anastomosis.
Caution must be exercised to preserve the regional branches of the SMA to the remaining colon (right colic and middle colic arteries). The mesentery can be divided as previously described and the vascular pedicles secured using traditional clamps and ties or a vessel sealer (LigaSure) before removal of the specimen en bloc. The anastomosis can be performed using a hand-sewn or stapled technique. A side-to-side (functional end-to-end) ileo–ascending colon anastomosis provides for a widely patent lumen and is the method of choice for reestablishing intestinal continuity. Either a hand-sewn or a stapled technique is applicable; however, stapled anastomosis may be associated with fewer leaks than the hand-sewn ileocolic anastomosis. In the event the ascending colon is not fully mobilized, an end-to-side anastomosis may be the technically more satisfactory option for reestablishing continuity between the ileum and colon. Finally, the mesentery is closed. Patients who undergo an ileocecal resection may experience more frequent bowel movements and watery bowel movements as a result of the loss of the ileocecal valve. This may also be associated with nausea due to reflux of colonic contents into the small bowel. Bowel function may improve with time, but patients need to be aware of initial changes of bowel function after ileocecal resection and possible long-term changes in bowel function.

**Transverse Colectomy**

The transverse colon and its mesentery may be directly infiltrated by bulky omental disease, or the associated fibrotic inflammatory tissue reaction may make separation along anatomic planes challenging. The omentum is divided from the lateral aspects of the transverse colon, and the lesser sac is entered. The transverse colon is then completely mobilized by dividing the gastrocolic ligament from the greater curvature of the stomach and taking down the lineolic ligaments to free the hepatic flexure and splenic flexure, respectively. The surgeon must ensure that the marginal artery of Drummond is intact and will provide sufficient blood supply to both ends of the planned anastomosis. A wedge-shaped section of transverse colon mesentery is demarcated by scoring the overlaying peritoneum, and the middle colic artery is identified, ligated, and divided distal to its origin from the SMA. If the marginal artery of Drummond is found to be discontinuous at the splenic flexure, the distal transverse colon and proximal descending colon are included in the scope of the resection. A colocolostomy is created to reestablish continuity via either an end-to-end or a functional end-to-end stapled or hand-sewn anastomosis.

**Right Hemicolecotomy in Conjunction With Omental Disease**

Extensive omental tumor involving the ascending colon or hepatic flexure warrants an en bloc right hemicolecotomy. The terminal ileum, cecum, and ascending colon, including the hepatic flexure, should be mobilized. The right colon is elevated off of the retroperitoneum by carefully freeing the mesentery from the underlying kidney, ureter, ovarian vessels, and inferior vena cava. The ileocolic and right colic arteries are carefully ligated and divided; they are included within the scope of the resection. In most cases, the right-sided branch of the middle colic artery will also need to be sacrificed, but the middle colic artery should be preserved. The anastomosis can be completed with one of several techniques by using a stapled or hand-sewn closure. A side-to-side (functional end-to-end) anastomosis between the terminal ileum and proximal transverse colon is commonly selected and seems to be associated with fewer anastomotic leaks. In select situations, end-to-end or end-to-side anastomosis, as previously described, may also be applicable.

**Left Hemicolecotomy in Conjunction With Omental Disease**

The descending colon is retracted medially after incising along the white line of Toldt, and the splenic flexure is mobilized by dividing the phrenocolic and lienocolic ligaments. Care must be taken during splenic flexure mobilization to avoid excessive downward traction, which could result in capsular tear to the spleen. The left colic artery is carefully isolated, ligated, and divided distal to its origin from the IMA. The middle colic artery should be identified and preserved; however, the left-sided branch may be incorporated within the scope of the resection. The intestine is then divided by using two applications of the linear GIA stapling device or between clamps. The anastomosis can be completed by means of one of several techniques with a stapled or hand-sewn closure. An EEA between the transverse colon and sigmoid colon is commonly selected.

**Rectal Resection**

Rectal resection is commonly performed by gynecologic oncologists in the setting of pelvic disease involving the pelvic peritoneum with sigmoid colon and/or rectum. The surgical resection of all or part of the rectum with a primary anastomosis is termed a *low anterior resection*. Most frequent indications are in patients with advanced ovarian cancer requiring a rectal resection as part of the debulking surgery, usually in the setting of an en bloc resection with uterus, cervix, upper vagina, and adnexa. Other indications include locally advanced endometrial cancer or cervical cancer or recurrent cancer surgery. The risk of anastomotic leak is greatest in rectal surgery because the perfusion may be compromised, and ensuring a tension-free anastomosis is more challenging than in the proximal part of the colon. Key components of a successful rectal resection are the integrity of the rectal wall during dissection of the mesorectum, resulting in poor perfusion and necrosis. A proximal diversion to protect the anastomosis should be considered for any patients who have had previous pelvic radiation or very low anastomosis (less than 5 cm) or if there is any concern about the integrity of the anastomosis (e.g., positive bubble test result).

Developing the proper surgical planes, maintaining the integrity of the rectal wall during dissection of the mesorectum, and mobilizing the proximal colon carefully and completely are key aspects of a successful rectal resection and anastomosis. When performed for rectal cancer, the operation includes a total mesorectal excision with an anastomosis at the level of the pelvic floor. For gynecologic cancers, the dissection stays outside the fascia propria and closer to the pelvic side walls to include the pelvic disease. Gynecologic cancers often grow above the peritoneal reflection, and very deep resections beyond the peritoneal reflection are uncommon. In general, a partial mesorectal excision with a 5- to 7-cm distal and mesorectal margin is often adequate. In this circumstance the anastomosis is usually performed at the midrectum. Once beyond the peritoneal...
reflection, the circumferential margin has no implications and adequate perfusion can be preserved.

To adequately perform a low anterior resection of the rectum with anastomosis, it is imperative that the descending colon be fully mobilized (Figs. 17.21 and 17.22). Typically the splenic flexure is released first by ligating omental attachments to the transverse colon and entering the lesser sac. Downward traction of the colon should be avoided, because this can cause omental attachments to the spleen to injure the splenic capsule. After the splenic flexure is freed, the descending colon can be further mobilized. Care should be taken to identify the gonadal vessels during the process of mobilization because they can be injured. Proper identification of the avascular planes is necessary to avoid injury to the posterior structures. An areolar plane exists between the mesocolon and the retroperitoneum; this allows the descending colon to be mobilized medially and lifted off the left kidney. The peritoneum on the right side can be opened above the sacral promontory and, underneath, the superior rectal artery can be divided. This allows entrance to the retrorectal or presacral space, which is avascular. The ureter on the left side needs to be lateralized and freed from surrounding structures. The uterine artery can be ligated lateral to the ureter and the ureter further freed, as in a radical hysterectomy. The IMA may or may not be ligated at its origin from the aorta. The IMV, which is situated more lateral to the IMA, can be dissected out separately and also ligated just inferior to the duodenum. Ligation of the IMA and/or IMV allows for excellent mobilization of the descending colon. The IMV should be ligated carefully because it may retract under the pancreas, and control of bleeding from the transected IMV can be challenging. The division of the IMA and IMV may not be necessary, but for a very low anastomosis, the division of these vessels is often required to achieve a tension-free anastomosis. As long as the marginal artery is not injured, the blood supply to the distal descending colon is adequate. The marginal artery runs parallel to the colon and only a few centimeters from the mesenteric border of the colon.

The rectum is surrounded by fatty tissue containing the mesentery and the lymphatics to the rectum itself. This tissue is enveloped by a thin layer of fascia, also known as the fascia propria. An avascular plane exists between the fascia propria and the presacral fascia. A thick layer of fascia connects the presacral fascia to the fascia propria of the rectum. Division of this fascia allows the rectum to be lifted from the sacral hollow and allows for lengthening of the rectum. The rectal mobilization begins with entrance to the retrorectal space at the level of the promontory. Laterally, the pelvic peritoneum can be mobilized, as well as bilaterally with careful consideration of bilateral ureters and infundibulopelvic ligaments.

For an en bloc resection, a retrograde hysterectomy is performed and a colpotomy is done anteriorly, and then bilateral uterosacral ligaments can be divided below the peritoneal reflection, allowing for anterolateral mobilization of the rectum. Again, care needs to be taken to lateralize bilateral ureters and avoid unnecessary injury to the distal ureters. Then the posterior colpotomy is performed, the important rectovaginal space is entered, and the endopelvic fascia can be divided. Significant length of the rectum can be spared by lifting the uterus, staying right underneath the peritoneal reflection. The rectum is then further mobilized anteriorly, laterally, and posteriorly. It is important to note that the rectal wall should not be skeletonized, but a circumferential ring of mesorectum should be preserved. Preservation of the rectum for the anastomosis is of great importance. Healthy and well-perfused
bowel must be available on either end of the anastomosis. The rectum can then be transected by using the TA stapler. Before the rectum is transected, both ureters should be identified outside of the TA stapler before the stapler is fired and the specimen transected. Once the specimen is removed, the vaginal cuff should be closed and the sutures should be left long; this will allow for proper visualization of the anastomosis, and tension on the vaginal cuff sutures greatly facilitates the exposure to the deep pelvis.

Typically an end-to-end surgical stapled (EEA) technique is used to complete the anastomosis. The previously described EEA stapler technique has allowed very low anastomoses to be performed that were previously thought to be extremely difficult with hand-sewn technique.

The size of the EEA stapler must be carefully selected to conform to the diameter of the colon and rectum. The most frequently used sizes range from 28 mm to 31 mm. The EEA stapler is introduced transanally (Fig. 17.23). The EEA trocar is advanced through the midportion of the linear staple line (Fig. 17.24) and matted to the anvil (Fig. 17.25). The EEA stapler is then closed carefully without traction until optimal approximation of tissue is indicated, after which it can be fired, released, and carefully removed (Figs. 17.26 and 17.27). The EEA stapler is dismantled, and two donuts of bowel (proximal and distal anastomosis) are removed from the stapling device. In all cases, they should be complete circles. If they are not intact circles, an incomplete anastomosis is likely, and the anastomosis should be taken down and repeated or the defect should be appropriately closed with sutures.
All anastomoses should be evaluated by examining the integrity of the doughnuts and then by air insufflation (bubble test). Proctoscopy may be used to inspect the circular staple line and assess the perfusion of the distal rectum and the proximal colon by using infrared imaging. Indocyanine green may be a helpful tool to evaluate perfusion of the anastomosis.\(^7\)

References
Bowel manipulation and resection are commonly performed in gynecologic cancer surgery. The principles of bowel surgery are discussed elsewhere in this book (see Chapter 17). This chapter focuses on frequent complications surgeons encounter during open and minimally invasive surgery (MIS) on the small and large bowel: special anatomy, vascular hemorrhage, solid and hollow-viscous organ injury, deep organ space infections, anastomotic complications, enterocutaneous fistulas (ECFs), blind loop syndrome, short gut syndrome with associated nutritional deficiencies, and bowel obstructions.

**Special Anatomy**

**Splenic Flexure**

Splenic injury has been associated with many procedures including omentectomy for tumor debulking and staging, and whereas historical reports reveal a 9% incidence, injury is now a rare event. Iatrogenic injury occurs most frequently during colorectal procedures (0.42%–3%) and is largely due to splenic flexure mobilization. Injury has also been reported during left nephrectomy (1.3%–24%), gastric operations (2%), reflux procedures (4%), and exposure and reconstruction of the proximal abdominal aorta or its branches (1%). Splenic capsular injury is initially managed conservatively with electrocautery or topical agents with success rates up to 17%, but a majority (76%) of patients ultimately require splenectomy for definitive hemorrhage control. A report by Merchea and colleagues revealed that of 13,897 col-nectomies, the locations of 71 splenic injuries were 24 (34%) inferior, 14 (20%) hilar, 3 (4%) posterior, 2 (3%) lateral, and 1 (1%) superior, with the location of 24 (34%) injuries not described. A frequent maneuver to increase exposure to the pelvis and retroperitoneal structures includes packing small bowel and omentum into the upper abdomen by first reflecting the omentum anterior to the liver in the right hemi-abdomen and left upper quadrant anterior to the stomach, in combination with nasogastric (NG) decompression. The bowel can then be compartmentalized with a radiopaque towel for protection. Owing to variable omental adhesions to the spleen and the splenocolic ligament, care must be taken during this maneuver not to tear the splenic capsule. Simple capsular injuries are initially managed conservatively with use of an electrocautery device on high settings and/or use of oxidized cellulose (Fibrillar or Surgicel), which can be removed at the end of the operation.

A self-retaining abdominal wall retractor is often necessary to provide adequate exposure to the left upper quadrant during splenic flexure mobilization for colon resection, or a left-to-right medial visceral rotation for exposure to the left retroperitoneal viscera and vascular structures. Medial and inferior traction on the descending colon during its mobilization off the white line of Toldt is necessary to adequately dissect the colonic mesentery free from the retroperitoneum. Use of right-angled instruments or even blunt finger manipulation may still produce enough tension to induce splenic injury during flexure mobilization. Attempts to immediately stop the resultant hemorrhage may not be easy with limited exposure and may cause inadvertent injury to the colon, stomach, small bowel, pancreas, or splenic artery and vein. Completing the splenic flexure mobilization facilitates adequate exposure and identifies the splenic injury, allowing appropriate control.

**Ureteric Injury**

Identification of the left ureter is typically required during rectal or colonic mobilization distal to the splenic flexure. The four most common locations of left ureter injury during colon and rectal mobilization include (1) the origin of the inferior mesenteric artery (IMA) off the aorta, (2) the left pelvis where the sigmoid mesentery is intimately associated with the retroperitoneum and the ureter courses over the left internal iliac artery, (3) the deep anterior pelvis as the ureter courses from lateral to medial heading toward the base of the bladder, (4) and under the bladder neck during the most proximal anterior dissection of the distal rectum and anal canal during an abdominal perineal resection (APR). The ureter is equally close to the uterocervical junction, and care must be taken during a hysterectomy to identify and protect it. Although ureteric stents have long been used to identify the ureters, the best and most predictive means is direct observation of the Kelly sign, peristalsis of the ureter with application of gentle pressure.
Although the anatomic path of the left ureter can be fairly well predicted, paired with the left gonadal vein in the retroperitoneum, its location can be largely unpredictable after any previous pelvic operation, pelvic radiation, or history of sigmoid diverticulitis with resultant inflammatory phlegmon. Injury remains low, around 0.2% to 7.8% of all pelvic surgical procedures, with elective colon and rectal operations accounting for 1% to 15% and gynecologic procedures up to 50% of all ureteral injuries in some series.\(^7\) During abdominal hysterectomy, injury incidence is low at 2.2% and 7.3% during hysterectomy with concurrent prolapse surgery\(^10\) and as high as 5% during radical hysterectomy alone.\(^11\) Use of ureteric stents with the intent of preventing ureteral injury has been controversial, with limited literature addressing the issue. To date, there has not been a randomized controlled trial to prove efficacy at preventing injury, although they have been useful in identification of injuries. Stents (lighted or nonlighted) can be readily seen at the time of a tangential or transection injury that may occur during a pelvic dissection. Immediate ureteral injury identification and repair are crucial to obtaining best outcomes and decreasing perioperative morbidity when compared with delayed identification and management.\(^9,12\)

Repair of a ureteric injury is dependent on two important factors: location and mechanism of injury. Thermal injury is a frequent cause owing to electocautery and occurs often during normal dissection or as an attempt at coagulation of adjacent tissue bleeding. Injury caused by sharp dissection is typically managed by primary repair with an absorbable, nonbraided suture placed over an indwelling stent, spatulated and anastomosed end to end if greater than 50% transection; simple repair can be performed primarily in transverse fashion if the injury is minimal. A spatulated end-to-end anastomosis is the repair of choice for injuries that occur in the proximal two-thirds of the ureter, because the injury is frequently a transection due to incomplete mobility of the ureter off the colon mesentery bringing it into the vascular bundle with the IMA. If the injury occurs deeper into the pelvis, on the distal one-third of the ureter, then reimplantation into the bladder as a ureteroneocystostomy is preferred and is completed with use of bladder mobilization and a Boari flap or psoas hitch repair.

**Vascular Anatomy**

Although it is anticipated that most individuals have the same general vascular anatomy, important variants exist, and knowledge of these helps provide a road map to safe operations and improved outcomes. Blood supply within the small bowel distribution has built-in redundancy with third-, fourth-, and fifth-order mesenteric arcades off terminal branches of the superior mesenteric artery (SMA) (see Fig. 17.1). Clinically significant jejunal or ileal vascular abnormalities are rare. In contrast, aberrant colonic blood supply occurs more frequently, and identifying variations proves important to ensuring adequate supply to any anastomosis.

The SMA supplies the entire small bowel, with the cecum and ascending colon supplied by the ileocolic artery (ICA) and the transverse colon supplied by the middle colic artery (MCA) with both right and left branches. A study by Gamo and colleagues evaluated both computed tomography (CT) imaging and cadaveric SMA branches; the vascular pattern consisting of a singular MCA, right colic artery (RCA), and ICA branches is expected, but Gamo and colleagues found that this was variable (between 40% and 73%).\(^13\) Additional variations center around a common trunk: RCA and MCA as one, with a separate ICA (20%); ICA and RCA with a separate MCA (32%); and a common trunk for all three (0.35%). The RCA is absent in approximately 8% of patients.\(^13\) They did not find any patients with an accessory RCA, but this has been reported in up to 18% of patients.\(^14\) The MCA also is absent in 2% to 21% of patients.\(^15\) Rarely, the IMA may originate from the SMA in a few individuals, with most originating from the anterior aorta.

The branches of the IMA typically consist of a left colic artery (LCA), with both left ascending and left descending colic arteries, several sigmoid branches, and the continuation of the IMA into the pelvis as the superior hemorrhoidal artery (SHA) (see Fig. 17.2). Often, these branches can be originating together at one large common trunk, making their dissection, identification, and control difficult.\(^16\) The inferior mesenteric vein (IMV) courses just laterally to the IMA branch point and ascends cranially along the left ascending colic artery to join the splenic vein. This normal anatomy can be confusing without proper identification, leading to frustratingly significant hemorrhage if not identified correctly before injury occurs.

Given that normal anatomy occurs less frequently than previously described, knowledge of aberrant vasculature is key to proper dissection and avoidance of inadvertent injury that may lead to vessel ligation or insufficient tissue perfusion and subsequent ischemia. Built-in arcades such as the marginal artery of Drummond (SMA to IMA) and the inconsistent meandering mesenteric artery (of Moskowitz), also known as the arc of Riolan (MCA to IMA), provide collateral supply to remaining bowel when major vessels are ligated, but this should not be relied on without sound understanding of each individual’s vascular supply (Fig. 18.1). Close attention to and review of preoperative CT scans or magnetic resonance imaging (MRI) findings will provide the surgeon with the necessary vascular road map to the viscera and optimum operative plan.

After vascular ligation and hemostasis, it is necessary to ensure adequate arterial supply to the planned anastomosis. Methods include palpation of the terminal arcade, such as the marginal artery for the colon, Doppler ultrasound of vessels to ensure arterial pulsatile flow, and use of fluorescence with a Wood lamp to confirm tissue perfusion. Newer technologies such as intravenous administration of indocyanine green (ICG) with laser immunofluorescence can also show tissue perfusion at Anastomotic sites. Although these methods are appropriate, there is nothing more confirmatory than controlled, sharp transection of the vessel to visualize pulsatile flow. If this flow is confirmed, adequate blood supply has been confirmed for an anastomosis to heal. The authors routinely use this last method in their practice. Hemostasis is then achieved with ties. If less than pulsatile bleeding is encountered, more proximal transection should be considered to ensure adequate blood flow; as a principle in bowel surgery, this should always be followed.

**Vascular Hemorrhage**

Advancements in surgical energy devices have expedited surgical procedures. Energy devices have been used for both MIS and standard open approaches, facilitating quicker vessel ligation...
with minimal bleeding risk. Although these energy devices can be expensive, they seal and ligate vessels 7 mm or less in diameter and reduce operative time and hemorrhage. Data exist to support the use of energy devices to transect vessels including the IMA with no additional risk of postoperative hemorrhage when compared with the other common methods of vascular transection, staples or clips; however, many surgeons are more comfortable using staplers with vascular loads during MIS approaches for major vessels. These devices can also be used during traditional open operations, but the authors favor a standard vascular ligation between clamps with suture ligature and ties.

Preoperative review of the major vasculature is paramount to understanding vascular anatomy and relationships with adjacent structures. Dissection of major vessels can be treacherous, especially during a repeat abdominopelvic operation or after pelvic radiation. If unanticipated hemorrhage is encountered, the fundamental principle of vascular surgery must be followed, gaining both proximal and distal control to properly identify the injury and not cause further injury (see Chapter 22). This is critical when dissecting along the aorta, its anterior visceral branches, lateral renal branches, and pelvic vessels branching off the common iliac artery and veins. A known cause of conversion from MIS to an open procedure is vascular hemorrhage, and surgeons should have a low threshold to convert to a hand-assisted or an open approach when significant hemorrhage is encountered. This is particularly important when operating in the lateral pelvis, and an open approach is nearly always necessary to control the bleeding that can develop with injury to these vessels.

Exposure is a key factor in addressing vascular hemorrhage; incisions should allow for maximum access, or poor visualization will prolong repair. Vessel loops are often used to encircle the vessels on both the proximal and the distal sides of injury once circumferentially dissected to gain control without causing further vascular injury. It is equally important to notify anesthesia providers when major bleeding is encountered, and intermittent direct pressure may be necessary to allow the anesthesia team to catch up with their resuscitation. Simple repair of these structures requires use of 4-0 or 5-0 monofilament permanent suture; however, if luminal compromise is a concern, a patch angioplasty with saphenous vein or bovine pericardium can be used, although typically this is performed by a vascular surgeon. Injured branches of the internal iliac artery and vein can be ligated; however, if control is not obtained, unilateral proximal ligation of the internal iliac artery can be performed. Additional bleeding can come from smaller bridging vessels that course along the internal iliac vessels. When bleeding is identified, use of simple monopolar cautery is typically insufficient to control it, but use of a bipolar energy device will usually provide adequate control. Standard clamp and tie methods are also adequate but can require a much longer time. Clips can also be used but often are dislodged during further dissection.
Extreme caution and careful dissection must be exercised while performing the splenic flexure mobilization, and the mesenteric dissection should be performed at the origin of the base of the colonic mesentery to avoid injury or inadvertent ligation of the marginal artery of Drummond (see Fig. 18.1). After dissection of the splenic flexure and major IMA ligation, if the marginal artery was inadvertently sacrificed, then the entire colon distal to the marginal artery transection site will become ischemic and offer less of a conduit for restoration of bowel continuity. This is especially important if trying to perform a low colorectal or coloanal anastomosis.

Significant bleeding can also develop during the posterior, low pelvic dissection, and dissection should proceed in the plane between the mesorectal fascia and the presacral fascia (Waldeyer fascia) (Fig. 18.2). Anterior dissection within the mesorectum results in injury to the SHA or superior hemorrhoidal vein (SHV) and is insufficient for oncologic rectal resection. Dissection within the mesorectum, anterior to the mesorectal fascia rectum, results in injury to the SHA or SHV and is insufficient for an oncologic rectal resection. Posterior dissection below the Waldeyer fascia results in injury to the presacral veins. Although the presacral veins are a low-pressure system, they carry a significant blood volume, and large blood loss occurs quickly. Instinctive use of cautery is frequently unsuccessful because the veins are prone to retraction into the sacral foramina. Suture ligation or bipolar forceps may prove useful but may still be insufficient, and the use of additional energy devices such as the argon beam coagulator and TissueLink (Medtronic, Minneapolis, Minnesota) has variable results. If hemorrhage has been unsuccessful with use of the previous methods, a square patch of rectus muscle can be harvested from the abdominal wall and sealed to the site of bleeding. With the cautery device on the highest setting and by using an arc welding technique, the surgeon holds the cautery device slightly away from the tissue and initiates welding of the muscle patch to the underlying tissue. If hemorrhage continues, pack the pelvis tightly, ensure control, abort the procedure, close the abdomen, and have the patient taken to the intensive care unit for continued aggressive resuscitation. A return trip to the operating room can be planned and additional assistance used as necessary within the 24 to 48 hours after stabilization.

**Iatrogenic Injuries During Minimally Invasive Surgery**

MIS is a major contribution of gynecology to the world of surgery. Many advances have occurred since the description of the first diagnostic laparoscopy, performed by Raoul Palmer, was published in 1947. In the modern era, complex surgical procedures once performed through laparotomies, such as pancreatic and liver surgical procedures, are now performed laparoscopically or robotically. As surgeons have gained more experience with MIS, they have also gained experience with complications unique to laparoscopy and how to manage them.

The cornerstone of MIS is safe access to the abdomen because it has the greatest potential for iatrogenic injuries. The most popular access techniques can be broadly classified as open or closed, and the most commonly chosen entry site is the umbilicus. A Cochrane review examined the risks of visceral and vascular injury between the two techniques and found no advantage to either technique. Thus the choice of open or closed entry into the abdomen is presently a product of preference, surgeon experience, and clinical judgment. The open technique, or Hasson technique, involves creating a 10-mm infraumbilical incision, isolating the umbilical stumps, and dissecting the subcutaneous tissue away from the anterior abdominal wall. The umbilical stumps are lifted away from the abdomen, and the linea alba is incised to reveal the peritoneum. Once the peritoneum is encountered, it is sharply incised and a finger sweep is used to detect adhesions of the omentum and viscera to the abdominal wall. The peritoneum is entered under direct visualization, and for this reason this technique is chosen often in patients with previous abdominal surgery.

The closed-entry technique uses a similar approach to identifying the umbilical stump; however, instead of incision of the linea alba, a Veress needle is inserted into the abdomen to establish pneumoperitoneum. Once this has been achieved, a trocar is inserted into the abdomen, and the abdominal contents are examined. Direct visualization is not used with Veress needle entry, so this technique is most often used in patients with a “virgin” abdomen, because there is minimal risk of abdominal wall adhesions. However, the danger of this technique lies in the failure to recognize signs of safe access. The Veress needle is spring-loaded, and the needle “clicks” as it passes through the layers of the abdominal wall. At the umbilicus, two clicks should be felt as the needle passes through the linea alba and then peritoneum. A drop of water passed through the needle should fall by gravity alone into the abdomen, and the linea alba is incised to reveal the peritoneum. If hemostasis has been unsuccessful with use of the previous methods, a square patch of rectus muscle can be harvested from the abdominal wall and sealed to the site of bleeding. With the cautery device on the highest setting and by using an arc welding technique, the surgeon holds the cautery device slightly away from the tissue and initiates welding of the muscle patch to the underlying tissue. If hemorrhage continues, pack the pelvis tightly, ensure control, abort the procedure, close the abdomen, and have the patient taken to the intensive care unit for continued aggressive resuscitation. A return trip to the operating room can be planned and additional assistance used as necessary within the 24 to 48 hours after stabilization.

Regardless of entry technique, one cannot underestimate the importance of understanding appropriate pressures from...
pneumoperitoneum. Although the classic two clicks of the Veress needle and hanging drop test can be helpful in determining correct placement, appropriate pressure from pneumoperitoneum has been shown to be the most sensitive predictor of correct intraperitoneal placement. Most experts would agree that less than 10 mm Hg of mercury is an appropriate opening pressure before the addition of pneumoperitoneum. A very high opening pressure is a clue that the Veress needle or trocar is within the abdominal wall, against the omentum or an adhesion, or inside abdominal viscera. If this occurs, bowel injury must be ruled out when correct access to the abdomen has been established. The volume of carbon dioxide needed to distend the abdomen has not been shown in any studies to be predictive of accurate intraabdominal placement; however in the authors’ experience, the abdomen should distend appropriately with 1 to 2 L of carbon dioxide. If no distention is observed with a large amount of gas, this is a sign that the intestinal lumen may have been accessed rather than the peritoneum.

Dealing with an iatrogenic trocar injury largely depends on the organ injured. Trocar insertion is a controlled, penetrating abdominal injury and can be treated similarly to a traumatic penetrating stab wound to the abdomen. There are three consequences of trocar placement: placement into the subcutaneous tissue, entry into the peritoneum without organ injury, and entry into the peritoneum with subsequent visceral or vascular injury. Leaving the trocar in place when an injury is suspected can help clarify the trajectory of the injury and which organs may have been damaged. In the infraurmiciblimal region, the organs and structures most likely to be injured are the omentum, small intestine and mesentry, and infraabdominal aorta or inferior vena cava. Signs that thorough exploration should be performed are bile staining, bleeding, or the presence of particulate matter such as stool or vegetable fiber. A small bowel injury can be managed laparoscopically or with open exploration depending on the comfort and experience of the surgeon; however, all intestinal surfaces from the ligament of Treitz to the terminal ileum should be visualized for a small bowel enterotomy, because the small bowel is highly mobile and injury can be missed. If the size of the small bowel enterotomy is less than half the diameter of the small bowel, primary closure of the intestine with suture can be attempted. If the injury is greater than one-half the diameter of the intestine or if multiple through-and-through injuries are present along a segment of small intestine, small bowel resection and anastomosis should be performed.

Major vascular injury is the second category of access injuries. A hard indication for exploration is the presence of rapid large-volume bleeding and hypotension, although this rarely occurs. Relative indications for exploration are more frequent and present diagnostic dilemmas. Expanding hematomas in the mesentery may indicate active bleeding that requires vascular repair. The retroperitoneum can hold a large volume of blood, and hypotension may not manifest immediately. In addition, the bowel wall may become dusky or very edematous. These signs should not be ignored, and consultation with general and vascular surgeons should be pursued if the gynecologic surgeon is uncomfortable with management. Typically, exposure of the aorta requires division of the white line of Toldt along the left colon and left-to-right medial visceral rotation. Exposure of the inferior vena cava requires a similar maneuver; however, a right-to-left medial visceral rotation is used to incise the right white line of Toldt. Timely recognition and exposure are key to addressing potentially devastating vascular injury.

A popular location for establishing access to the abdomen is in the left upper quadrant, known colloquially as the Palmer point. Many surgeons choose this entry site in patients with previous midline incisions. Once pneumoperitoneum has been established, adhesiolysis of any midline adhesions is performed, and subsequent trocars are placed under direct visualization. Special considerations in this location include injury to the stomach, spleen, and splenic flexure of the colon. The stomach is a very resilient organ; however, injury seen on the anterior stomach wall should be addressed, and a posterior through-and-through injury should be ruled out. The posterior stomach wall is best explored by dividing the gastrocolic ligament and short gastric vessels of the greater curvature and entering the lesser sac. Punctate gastric injuries can typically be repaired primarily with absorbable suture.

Spleenic lacerations usually have self-limited bleeding, and direct pressure with use of hemostatic agents such as oxidized cellulose (Surgicel, Fibrillar) is often sufficient. Electrocautery to the spleen is sometimes successful but can lead to more bleeding if aggressive cauterization is pursued and additional splenic capsule injury occurs. All attempts should be made to save the spleen owing to its immunologic functions; however, continued bleeding may necessitate splenectomy. Emergent splenectomy, particularly associated with hemorrhage, can be morbid and has the complications of damage to the pancreatic tail, pancreatitis, gastric fistula, pneumonia, and overwhelming postsplenectomy sepsis (OPSS). Although vaccinations for encapsulated bacteria after splenectomy have come into question, patients with malignancy seem to be at high risk for OPSS, and vaccines should be considered in this population after splenectomy.26,27 The splenic flexure of the colon is repaired similarly to other sites along the intestines. Through-and-through injuries should be evaluated for by mobilizing the splenic flexure, medially rotating the colon, and inspecting all surfaces for injury. Because the colon has a relatively large lumen, most injuries can be repaired primarily with suture. Use of single-layer or classic two-layer closure is surgeon dependent. However, injury that is greater than 50% of the diameter of the colon may necessitate partial colectomy.

Areas of special interest to the gynecologic oncologist include organs of the pelvis. Trocar injuries to the inferior epigastric vessels can cause insidious arterial bleeding that may not manifest for hours postoperatively and sometimes necessitate transfusion if missed. One technique is to retract trocars into the abdominal wall and observe for excessive bleeding from port sites before closing. A transfascial suture placed through the abdominal wall to occlude the vessel can be particularly effective in controlling bleeding, and direct cut-down and exploration can be bloody, frustrating, and unsuccessful. Bladder injury may occur from trocar placement, with dissection of the uterus anteriorly during hysterectomy, or with low, suprapubic trocar placement. Ideally, cystoscopy is performed intraoperatively; however, some surgeons have injected dilute methylene blue in a retrograde manner through the Foley catheter to distend it. Leakage of blue fluid confirms a bladder injury. Injuries to the bladder can be repaired
primarily with a nonlithogenic, absorbable, monofilament suture, and a Foley catheter should be placed to keep the bladder decompressed until healing has occurred. A retrograde urethrogram can demonstrate an intact bladder repair before removal of the Foley catheter.

The rectum also deserves special consideration during gynecologic surgery because of its close association to the vagina and potential for damage during hysterectomy. Unlike the rest of the colon, the rectum does not have a serosa below peritoneal reflection. This can make repair very challenging. Rectal injury less than 50% of the diameter of the rectal lumen can be repaired primarily with suture after proper dissection of the mesorectum to identify the rectal wall. A pedicled omental flap can be placed over the repair if an omentectomy has not been performed for oncologic reasons for added protection against enteric leakage and prevention of rectovaginal fistula. Insufflation of the rectum with a colonoscope or rigid sigmoidoscope while the rectum is submerged under irrigation can help detect the presence of injury or leak that may have been missed. Rectal injury involving more than 50% of the rectal lumen should require resection and anastomosis. The most conservative approach would be a resection of damaged rectum (also known as a low anterior resection) and consideration of a diverting stoma. However, if the tissue is of good quality and the injury is more than 7 cm from the anal verge, a transanal, stapled rectal anastomosis can be performed. If the tissue is of poor quality because of previous pelvic irradiation, a colorectal anastomosis may still be attempted with a temporary diverting ileostomy and additional pedicled omental flap to allow the anastomosis to heal and to help prevent pelvic sepsis if an anastomotic leak develops.

A final consideration is proper closure of trocar sites to prevent trocar site herniation and possible intestinal strangulation. The reported incidence is very rare in gynecologic patients. Many laparoscopists vary on their opinion in closing trocar sites, because this is a possibly preventable and rare but potentially devastating complication. Some authors argue that morbidly obese patients do not require closure of port sites because their fatty omentum, rather than small intestine, has a higher likelihood of herniating. Other authors close all port sites transfascially regardless of size, and still others selectively close all trocar sites 10 mm or larger. High-level evidence is lacking for best practice; however, because some gynecologic patients may undergo omentectomy, it may be prudent to consider transfascial port site closure in a gynecology population.

Deep Space Surgical Site Infections

Of all surgical infections, the diagnosis and management of deep space infections can be the most vexing. They often manifest insidiously with vague, nonspecific symptoms including dull, burning abdominal pain; nausea; vomiting; ileus; masses; or leukocytosis or, in the case of older patients, sometimes no symptoms at all. The most common deep space infections are from bacterial flora from gastrointestinal contamination, in particular *Bacteroides*, *Escherichia coli*, *Streptococcus*, *Enterococcus*, and fungi. There are eight classic locations for deep space surgical infections: subphrenic, lesser sac, hepatic, retroperitoneal, paracolic, interloop (between loops of small bowel), periappendicular, and pelvic. The mainstay of treatment for all deep space abscesses is removal of the septic focus and its associated abscess through drainage (Fig. 18.3).

Diagnosis of deep space infections is typically made with CT. Patients who are highly suspected to have an abscess should undergo CT scanning with intravenous and oral contrast because it provides the most useful anatomic information and can be therapeutic if combined with interventional radiology (IR)-guided drainage. Previously, mortality of intraabdominal abscesses approached 33%, but with improvement of interventional techniques, IR-guided drainage is now standard of care for accessible intraabdominal abscesses, with success rates reaching 82%, 34, 35 IR-guided drainage is most successful if the abscess is well defined, is larger than 3 cm, and has minimal debris; it provides minimal morbidity to the patient if it can be performed.

IR-guided drainage is usually best achieved in the pelvis owing to the difficulty of surgical drainage in a compact anatomic space that contains critical structures. High success rates of IR-guided pelvic drainage in older women with large tubo-ovarian abscesses and a history of pelvic inflammatory disease have been reported. Subphrenic and lesser sac abscesses are sometimes challenging because the radiologist may need to cross the pleural space to drain the abscess. This confers the risk of pneumothorax and subsequent empyema; the risk of drainage needs to be weighed against a trial of observation on antibiotics. Interloop abscesses are not typically amenable to IR-guided drainage because of potential iatrogenic bowel injury and subsequent fistula. These are mostly managed nonsurgically with antibiotics unless persistent sepsis forces the surgeon to operate. Related inflammation causes the intestines to become friable and increases surgical morbidity, predisposing the patient to anastomotic breakdown and fistula if bowel resection is required. The retroperitoneum is usually best accessed with IR drainage because of the thick back musculature and difficulty of finding an abscess by palpation. Retroperitoneoscopic debridement has been described in selected centers, but it is challenging and best left to surgeons with experience with the technique. Timing to drain removal is not well studied, but most experts would remove the drain once abdominal pain, leukocytosis, and drain outputs have decreased significantly from baseline.

Special considerations for the gynecologic surgeon are management of appendicitis and pelvic abscess. In cases of severe pelvic infection, abscess formation from acute appendicitis and tubo-ovarian abscess can be hard to differentiate with imaging. Current management of tubo-ovarian abscess is antibiotics followed by surgical drainage procedures for sepsis or hemodynamic instability. Similarly, appendicitis can be managed nonoperatively; this method has already gained popularity in Europe as the initial treatment for perforated appendicitis. It may be feasible to consider a trial of antibiotics and IR-guided drainage if the cause of the pelvic abscess is unclear. Returning to perform an interval appendectomy is controversial at this time; however, there may be support for removal of the appendix in patients older than 40 years to rule out the possibility of occult appendiceal malignancy. Most general surgeons do not support interval appendectomy at this time, because the risk of recurrent appendicitis is less than 30%.

Sometimes, a hostile pelvis due to abscess or pelvic inflammatory disease is encountered when surgical management of tubo-ovarian abscess is required, and the question of performing a coincidental appendectomy arises. The official stance of the American College of Obstetricians and Gynecologists is
that coincidental appendectomy is controversial and should be based on individual patient scenarios. The decision to pursue appendectomy should involve consideration of the severity of pelvic inflammation and the possibility of staple line breakdown if the cecal tissue is of poor quality. In the absence of gangrenous appendicitis, most surgeons would favor observation on antibiotics and would reconsider appendectomy in 4 to 6 weeks once inflammation has resolved. Leaving a pelvic drain in place for the prevention of pelvic abscess after appendectomy has not been proven to be beneficial through systematic reviews, and the use of such drains should be considered based on clinical judgment.

The end point of antibiotic therapy after definitive drainage has not been highly studied and typically is left to the surgeon’s judgment. Basic principles of antibiotic stewardship should be practiced in order to prevent superinfections such as *Clostridium difficile* colitis. Commonly, broad-spectrum antibiotics are initiated, and abscess cultures are sent for determination of antibiotic sensitivities. Antibiotic coverage is then tailored to the sensitivity of the pathogen. Most infectious disease specialists recommend discontinuation of antibiotics once the septic focus has been removed; however, clinically, most surgeons would continue antibiotics until pain and leukocytosis resolve. This typically happens within 24 to 72 hours. Fecal transplantation may be a promising modality for treatment, but its use remains under the direction of institutional review board–approved protocols.

**Anastomotic Complications**

One of the most dreaded complications of intestinal surgery is an anastomotic leak. Leak rates outside the pelvis should be very low but incrementally increase the lower the anastomosis is created in the low pelvis. As a rule of thumb, for every 5 cm the anastomosis is created distal to the top of the rectum, the leak rate increases by about 5%, resulting in cumulative rates of 5% to 15%; the highest leak rates occur in patients with a low colorectal, or coloanal, anastomosis at or below 5 cm from the anal verge (Fig. 18.4). Anastomotic complications can be defined as acute (developing in the immediate postoperative period) or chronic (developing up to years after creation of the anastomosis). Acute complications include stapler malfunction, hemorrhage, intramural hematoma, leak, dehiscence, ischemia, and stenosis; chronic complications include stenosis and dysfunction (Fig. 18.5), typically managed by conservative dilation or ultimately revision. In performing any intestinal anastomosis, including esophagus and anus, there are two principles that must be strictly followed: there should be zero tension, and blood supply must be adequate. It is the opinion of the authors that the majority of anastomotic complications can be linked to violation of one of these two principles. This section focuses on the acute anastomotic complications.

**FIG. 18.3** Suggested algorithm for managing pelvic abscess and appendicitis. IR, Interventional radiology.

Acute Complications

A stapler misfire that occurs when a linear stapler is used outside the pelvis is less clinically significant than for intra-pelvic colorectal or anal anastomoses. Stapler misfires can occur both when the bowel is transected and when continuity is reestablished. To avoid a misfire, care must be taken to ensure adequate dissection of the mesorectum, essentially skeletonizing the rectal wall to decrease tissue thickness, allowing for appropriate staple height and seal. The upper and middle portions of the rectum typically have a very thick mesorectum and likely make the seal incomplete if included in the stapler device. In addition, the diameter of the upper and middle rectum in these locations can be very wide, necessitating multiple reloads (increasing the risk of stapling over staples, which increases the leak rate) or a longer stapler load. If the stapler misfires, attempted stapler removal should be performed; if one is unable to open the stapler jaws, the distal rectum may need to be sharply divided. If the jaws can be opened and the stapler was engaged but did not transect the bowel, then transection between the staple lines can be performed. Further consideration of a diverting stoma should be entertained.

Use of an automated purse-string stapler device on the proximal bowel to secure the anvil is quick but may fail with even minimal tension placed on the anvil. For this reason, the authors routinely secure a running, hand-sewn 2-0 Prolene full-thickness horizontal mattress purse-string suture, starting on the outside of the bowel at the most anterior aspect of the transected colon. Although full-thickness suturing is desired, the surgeon should include the outer serosa and a minimal amount of mucosa with each pass of the needle. This will ensure that the entire bowel wall is included in the circular stapled anastomosis and will not create a situation in which the resultant donuts are too thick. If the donuts are too thick, it likely reflects incorporation of a large amount of tissue, putting undue stress on the staples and possibly increasing the leak rate, although no study has proven that idea. Care should be taken to not secure the anvil in such a way as to incorporate a diverticulum, because this also could contribute to leaks.

If a circular stapler is used to create a colorectal or anal anastomosis, several key points should be kept in mind to ensure the lowest risk of complications. Although there are no data to support an ideal location, the authors attempt to advance the spike just posterior to the staple line. If placed too posteriorly, the

FIG. 18.5 (A) Anastomotic leak. Free air visible on upright chest radiograph increased over a 2-day period. (B) Anastomotic leak with retroperitoneal air (left) and free fluid around the staple line (right) (arrows). (From Bailey HR, Billingham RP, Stamos MJ, Snyder MJ, eds. Colorectal Surgery. Elsevier, Philadelphia; 2011.)
Enterocutaneous Fistulas
In the simplest definition, an ECF can be defined as an abnormal connection between the epithelial-lined gastrointestinal system and the skin. Up to 85% of ECFs develop after a surgical procedure. Anastomotic leaks and leaks that arise from inadvertent bowel injury remain a significant clinical challenge, and their management has been divided into three steps: diagnosis and recognition, stabilization and investigation, and definitive care. When ECF is diagnosed, the skin should be opened enough to facilitate drainage as needed. If the ECF arises from a surgical incision, it may need to be opened widely and managed with a wound manager, a large system typically placed and managed by the wound, ostomy, and continence nurses. If the effluent does not require reopening of the incision, then an ostomy appliance should be placed to control and measure the effluent while protecting the skin from excoriation. This is a key initial step in the management of an ECF, because accurate measurement of the daily output is necessary to guide the appropriate management strategy. Fistula output can be high (>500 mL/day), moderate (200–500 mL/day), or low (<200 mL/day). There is conflicting literature stating that spontaneous closure rates are equal for high- and low-output fistulas, although, in theory, high-output fistulas would seem less likely to spontaneously close. Despite advances, spontaneous ECF closure rates continue to remain between 15% and 30%. Once ECF has been diagnosed, investigation and immediate control of the leak must be performed. If the patient’s condition is clinically stable, a CT scan of the abdomen and pelvis with contrast material should be performed, IR practitioners consulted to place as many drains as necessary to control the leak if undrained abscess is noted, and broad-spectrum antibiotics started, preventing further sepsis. Drain placement creates and establishes a controlled ECF in the event that no drainage has occurred through the skin.

After stabilization with leakage control, a soluble contrast injection study (fistulogram or sinogram) should be performed to identify the origin of the leak. This can be difficult in the setting of multiple bowel injuries or anastomoses at the original operation. ECFs can quickly deplete patients of their fluid, electrolytes, and nutrition, rendering them significantly malnourished. Optimizing nutrition can be difficult for higher output fistulas, and total parenteral nutrition (TPN) is often needed to ensure patients remain euvoletic, in a positive nitrogen balance, and without electrolyte abnormalities. A trial of oral intake is appropriate, and close monitoring of total daily output is needed to ensure that the output does not increase to above 200 to 500 mL/day. If the output increases, then patients are placed on strict nothing-by-mouth (NPO) status, and TPN will be necessary. However, if the output remains low and patients can maintain adequate oral nutritional requirements, TPN is unnecessary. Patients should be placed on a proton pump inhibitor, and octreotide should be considered in an attempt to decrease gastric, pancreatic, and small bowel secretions. Octreotide dosage has been reported to start at 100 μg intravenously every 8 hours and may be increased up to 300 μg every 8 hours based on clinical response; a trial is conducted for up to 3 days, and if no response occurs the therapy is stopped. Although use of octreotide has been reported to increase spontaneous ECF closure rates in up to 70% of patients, other researchers have reported rates of 25% to 30%; accordingly, octreotide is often reserved for high-output ECFs as a means to decrease fluid and electrolyte loss. Nutrition and electrolyte laboratory values should be monitored weekly while the patient is on TPN to optimize nutrition, and weight gain can serve as a sign of positive nitrogen balance—the optimum condition for surgical repair.

Surgical repair of an ECF remains the most common and successful management strategy, although it is not an easy decision because a hostile abdomen may be anticipated. Success rates are variable and have remained at around 75% to 85% over time, with mortality rates of 5% to 20%. The more time that passes between ECF diagnosis and surgical intervention, the better the chances may be for a successful repair while avoiding an operative misadventure, although no Level 1 evidence exists to support this claim. The authors wait at least 3 months before reexploration—a period that is often required for patients to achieve adequate nutritional status for such an endeavor. Entrance into the abdomen should occur both above and below the ECF site, and the skin should be incised as an ellipse around the cutaneous opening. Once the abdomen has been entered, the adhesions are lysed and the tract to the skin is traced to the origin of the leak. A fistula probe can be placed into the tract if its course is not easily identified. The ECF should be resected en bloc with the bowel resection so as to minimize...
any risk of cutting across tumor if the original operation performed was for cancer. In addition, it is paramount to ensure that the appropriate oncologic resection was performed; if not, this should be completed as part of the repair. The surgeon must also be prepared to encounter chronic ischemia (potential cause of the leak) and to re-resect bowel, provided there is no tension on the reanastomosis with adequate pulsatile bleeding at the margin. If a prior side-to-side functional end-to-end anastomosis was created, then an isoperistaltic side-to-side anastomosis should be considered. Regardless of anastomosis technique, a repeat of the original type should be avoided. If the ECF originates from a bowel injury or site other than an anastomosis, then simple resection and reanastomosis should be performed. If any bowel dilatation from partial or complete obstruction is present, resection with primary anastomosis, resection with anastomosis and additional proximal diversion, or diversion alone must be strongly considered. Postoperatively, initiation of oral feeding may be advanced according to the physician’s instructions; however, weaning from TPN and initiating oral feeding too quickly may result in refeeding syndrome.

Very few studies on additional nonsurgical techniques for ECF management have been reported. Such techniques include the use of fistula plugs and fibrin glue. Variable results with poor success have been reported, and no data are convincing for the routine use of these methods as first-line measures.57,58 Their use should be considered in patients with long tracts or if an operation is contraindicated because of comorbidities.

**Blind Loop Syndrome and Intestinal Bacterial Overgrowth**

Blind loop syndrome is a condition that represents bacterial overgrowth of a segment of bowel that is no longer in continuity with the passage of chyme. The bowel is a dynamic organ with diverse microflora, and the inability of migrating motor complexes to sweep the gut can allow hydrogen- and methane-producing bacteria to produce excess gas. Examples of blind loops include the remnant stomach in patients who have undergone a roux-en-Y gastric bypass procedure or patients with malignant obstruction who have undergone a small bowel bypass operation.

Symptoms are diverse, but bloating, flatulence, abdominal pain, fatigue, diarrhea, and constipation are generally reported. Physical findings are not well reported, and the broad array of presenting symptoms has little predictive value in establishing the diagnosis of bacterial overgrowth.59

The gold standard for diagnosis is an endoscopic aspiration of small bowel fluid followed by cultures and bacterial counts. An actual bacterial count has not been well established; endoscopy may not reach the areas in question. In addition, this procedure is invasive and expensive. Hydrogen and methane gas chromatography—that is, a “breath test”—has been the more acceptable approach to diagnosis owing to its noninvasiveness and cost-efficiency. Glucose or lactulose is ingested, and the patient’s breath is sampled every 15 minutes for 3 hours; a positive test results demonstrates an increased level of hydrogen and methane relative to ambient air.59

The mainstay of treatment is antibiotics, and rifaximin has been the most studied.60 Regimens vary, as do the end points of treatment, but in general most patients are treated until their presenting symptoms resolve. A meta-analysis has suggested that patients with a positive breath test result for hydrogen- and methane-producing bacteria can be treated with rifaximin and neomycin for 14 days, and if clinical response is achieved, one monitors for recurring symptoms because intestinal overgrowth is a relapsing and remitting disease.59

**Postsurgical Nutritional Deficiencies and Short Gut Syndrome**

After extensive bowel resection, nutrition can be compromised (see Table 17.1). Basic knowledge of physiologic gut function and anatomy is useful in anticipating postsurgical changes. In the upper gastrointestinal tract, history of gastrectomy can have the most profound effects on nutrition. With the rise of bariatric procedures such as roux-en-Y gastric bypass and sleeve gastrectomy, nutritional changes caused by exclusion or resection of the stomach can occur. In both of these procedures, the parietal cells of the stomach, which secrete intrinsic factor, can decrease the absorption of vitamin B12.61 This results in pernicious anemia, and these patients often require supplemental injections. In particular for roux-en-Y gastric bypass, the duodenum is bypassed. The duodenum plays a critical role in the absorption of iron, vitamin D, and zinc.61 Periodic infusion of iron to prevent iron deficiency may be needed in these patients. In addition, because vitamin D is a cofactor in calcium reabsorption, replenishment of low vitamin D levels and monitoring for hypocalcemia are also necessary.

In the midgut, the function of the small bowel is primarily related to reabsorption of carbohydrates and amino acids. Thus, removal of large segments of small bowel can result in protein malnutrition. The classic teaching is that a minimum of 100 cm of small bowel is necessary to avoid supplemental nutrition.62 However, because the length of the small bowel is variable among patients of different height and sex, most experts would agree that loss of 75% of a patient’s small intestine may lead to short bowel syndrome.63,64 Most pediatric literature highlights the role of a competent ileocolonic valve in intestinal failure because it prevents diarrhea, potentially increasing transit time and reabsorption of nutrients.65,66

The features of short bowel syndrome include diarrhea, malabsorption, and weight loss.64 Nutritional deficiency in this setting can be hard to manage. Many patients may require home parenteral nutrition; subsequent challenges include frequently needed medical supplies and sepsis from line infection. Specialized centers have developed intestinal rehabilitation programs to take advantage of advances in specialized oral diets, soluble fiber, oral rehydration, and trophic factors to enhance absorption.67,68 In extreme cases, patients have undergone small bowel transplantation; however, this remains a difficult procedure complicated by high rejection rates and sepsis.69

**Obstructions**

Pelvic surgical procedures—in particular, hysterectomy—can predispose patients to bowel obstructions secondary to adhesions, volvulus, and internal hernias from adhesive bands. For patients undergoing hysterectomy, Montz and colleagues found the incidence of small bowel obstruction to be 5% in patients without previous pelvic radiation and 20% to 22% in those with pelvic radiation preoperatively and postoperatively.70 Adhesion rates are similar in patients undergoing a total abdominal, transvaginal, or laparoscopic hysterectomy.71 However, a large
systematic review found that use of cellulose barriers does help prevent adhesions.72 Other commonly missed causes of bowel obstruction in the pelvis include incisional and inguinal hernias that progress to incarceration or strangulation of intestine. Bowel that becomes ischemic and strangulated at points of obstruction becomes a surgical emergency, and timely diagnosis is of high importance.

Advances in imaging technology and clinical experience have made CT the highest yield study for diagnosing bowel obstructions (Fig. 18.6). The old adage "Never let the sun set on a bowel obstruction" has been challenged, with operation being reserved for patients who develop peritonitis or have signs of bowel ischemia or perforation at imaging. Classic signs of bowel ischemia on CT scans include intramural thickening, pneumatosis intestinalis (gas in the wall of the bowel), "fecalization" of the small bowel (stool-like appearance of small bowel intestinal contents), and free fluid. A "swirled" appearance of the mesenteric vessels and mesenteric edema may indicate an intestinal volvulus secondary to internal hernia around an adhesive band (Fig. 18.7). A meta-analysis showed that bowel wall thickening increased the chance of surgical ischemia by 11-fold, and the absence of mesenteric fluid decreased the probability of strangulation by 6-fold.73

Patients without signs of peritonitis can often be managed with NG decompression, restriction of oral intake, and intravenous fluid hydration (Fig. 18.8). Placement of an NG tube without some form of suction applied is unlikely to provide decompression to the patient’s bowel; therefore suction should be applied rather than placing an NG tube to gravity. Initial bilious output can be quite impressive, and up to 2 L can be produced on initial placement. Because the stomach produces 1 to 2 L of fluid daily, a daily NG output of 200 to 500 mL in addition to flatus is often seen as the end point to NG decompression. Most literature surrounding diet advancement focuses on postsurgical patients rather than those treated nonsurgically; however, most surgeons tend to start with clear liquids and advance to full liquids and soft diet over the subsequent 24 to 48 hours if well tolerated by the patient. Failure to have return of flatus by 72 hours may indicate the need for operative intervention. An adjunctive study used by many surgeons in this setting is a small bowel follow-through using oral (water soluble) Gastrografin followed by serial abdominal plain films to document passage of contrast into the colon.74 Although barium is preferred by radiologists because it provides detailed images, surgeons do
not favor its use, because retained barium in the face of bowel obstruction can cause concretions within the intestines and compromise potential surgical outcomes if bowel resection and anastomosis are indicated. The proposed mechanism of action is the osmotic pressure of the Gastrografin into the small intestine, causing quicker nonoperative resolution of obstruction.\textsuperscript{75}

Up to this point, management of benign bowel obstructions has been described; however, 22% of bowel obstructions can occur secondary to malignant causes such as visceral metastasis, carcinomatosis, and tumor recurrence.\textsuperscript{76} Intraluminal small bowel obstruction is rare but can be secondary to melanoma, gastrointestinal stromal tumor (GIST), and adenocarcinoma.\textsuperscript{77} In gynecologic patients, the incidence rates of small bowel and colonic obstruction in ovarian cancers have been reported to be 44% and 33%, respectively.\textsuperscript{78} Patients with suspected malignant and bowel obstruction should have gastric and colonic malignancy ruled out with endoscopy first, because these areas are easily accessible. Traditionally, the main limitation of endoscopic small bowel evaluation has been its inaccessibility, and thus small bowel follow-through, CT imaging, and exploratory laparotomy have been employed. Pill endoscopy and double-balloon endoscopy are newer modalities that show promise without the morbidity of laparotomy, but these may be available only in larger centers. In the setting of a bowel obstruction, either partial or complete, the authors do not advocate use of pill endoscopy because such procedures may facilitate bowel obstruction.

Treatment of malignant bowel obstruction depends on the underlying pathology. Mucosally derived cancers should be evaluated by surgeons for resectability or the need for neoadjuvant chemotherapy and radiation. Of special interest to gynecologists, however, are bowel obstructions caused by diffuse peritoneal malignancies, such as metastatic ovarian cancers. Palliative interventions, such as enterocenterec bypass or proximal diversion, for these patients can be considered. Although these procedures are not curative, quality-of-life improvements such as alleviation of bowel obstructive symptoms, the ability to tolerate diet, and discharge can be achieved in 75% to 85% of patients.\textsuperscript{79}

References
18. Lamberton GR, et al. Prospective comparison of four laparoscopic ves-
19. Marcello PW, et al. Vascular pedicle ligation techniques during laparo-
23. Teoh B, Sen R, Abbott J. An evaluation of four tests used to ascertain Veres needle placement at closed laparoscopy. J Minim Invasive Gyn-
24. Vilos GA, et al. Laparoscopic entry: a review of techniques, technolo-
25. Qu Y, et al. Management of postoperative complications following sple-
26. Thellacker C, et al. Overwhelming postsplenectomy infection: a pro-
33. Bodmann KF. Complicated intra-abdominal infections: pathogens, resist-
34. Cinat ME, Wilson SE, Din AM. Determinants for successful percut-
36. Goharkhay N, Verma U, Maggiroletto F. Comparison of CT- or ultra-
sound-guided drainage with concomitant intravenous antibiotics vs. intravenous antibiotics alone in the management of tubo-ovarian ab-
39. Wright GP, et al. Is there truly an oncologic indication for interval ap-
40. Andersson RE, Petzold MG. Nonsurgical treatment of appendiceal ab-
42. Pakula AM, et al. Role of drains in laparoscopic appendectomy for com-
46. Wong NY, Eu KW. A defunctioning ileostomy does not prevent clinical anastomotic leak after a low anterior resection: a prospective, compara-
47. Eveson AR, Fischer JE. Current management of enterocutaneous fis-
48. Foster 3rd CE, Lefor AT. General management of gastrointestinal fis-
54. Torres AJ, et al. Somatostatin in the management of gastrointestinal fis-
58. Rabago LR, et al. Endoscopic treatment of postoperative fistulas resis-
tant to conservative management using biological fibrin glue. Endos-
61. Stein J, et al. Review article: the nutritional and pharmacological conse-
64. Stollman NH, Neustatter BR, Rogers AI. Short-bowel syndrome. Gastro-
67. Matarese LE, et al. Short bowel syndrome: clinical guidelines for nutri-
70. Montz FJ, et al. Small bowel obstruction following radical hysterec-
A fellowship-trained gynecologic oncologist is expected to be competent in performing gynecologic, gastrointestinal, urologic, and vascular procedures relevant to gynecologic malignancy management. Urologic injury is a known risk factor of pelvic and retroperitoneal surgery in general and in gynecologic surgical procedures in particular. Urologic injuries during gynecologic operations can cause significant morbidity and if not identified immediately can delay recovery and necessitate several additional procedures. The vast majority of published studies describe outcomes from gynecologic surgery for benign conditions, with few specifically addressing gynecologic oncologic surgical morbidity. During gynecologic oncologic procedures, not only is the anatomy altered by large tumors and diffuse pathology, but urologic organs may be directly involved with tumor, and so it is important to know how these injuries or planned urologic resections are diagnosed and managed and how to be vigilant about potential postoperative complications for early identification and management.

Ureteral Injuries and Management

The course of the ureter makes it a prime organ for injury and involvement during gynecologic surgical procedures. Although it is located posteriorly in the retroperitoneum, it is in close proximity to the uterus and upper vagina and their associated vessels (Fig. 19.1). Ureteral injury can cause significant morbidity, prolonged hospital admission, repeat operative procedures, renal insufficiency, and reduced quality of life and can even result in legal action. In fact, “It is the most common non-obstetric complication leading to legal action against gynecologists.”

Seventy-five percent of the injuries to the ureter in general are iatrogenic, with 73% of these resulting from gynecologic surgical procedures, mostly involving the lower ureteral segments. Ureteral injury is reported to occur at an overall frequency of 1.6 per 1000 cases, with only 11.5% of these injuries recognized intraoperatively. It most commonly occurs during abdominal hysterectomies (0.04%–3.0%), laparoscopic or robotic hysterectomies (0.19%–6.0%), and vaginal hysterectomies (0.02%–0.47%).

If not recognized intraoperatively, the diagnosis of a ureteral injury is made postoperatively when high clinical suspicion arises. There are no specific or discreet symptoms for ureteral injury. Preventative measures such as intraoperative placement of temporary ureteral catheters or stents, routine use of cystoscopy, and near infrared (NIR) fluorescence imaging are sometimes used to identify the course of the ureter and to attempt to minimize the risk of ureteral injuries. The use of cystoscopy was studied in a meta-analysis by Gilmour and colleagues, who found that it revealed up to 90% of unsuspected ureteral injuries. This study focused mostly on benign gynecologic cases but still shows the usefulness of intraoperative cystoscopy in this setting. Indocyanine green (ICG) can be used for ureteral identification because it binds urothelial proteins. It has been shown to be effective in ureteral identification in robotic and laparoscopic procedures in which tactile feedback and two-dimensional viewing do not allow for ready identification of the ureter. In a study by Siddighi and colleagues of 10 patients, the authors were able to visualize the course of the ureter by using ICG and NIR laser imaging with the da Vinci robotic system (Intuitive Surgical, Sunnyvale, California). However, difficulty in ureteral identification was noted in morbidly obese patients. The patients were followed for 2 months postoperatively with no sequelae from the intravenous dye administration. Korb and colleagues performed a study involving the use of IRDye800CW, a renally excreted fluorescent dye with absorption and emission spectra that overlap those of ICG and therefore allow the same imaging modality to be used. This dye was tested in a laparoscopic setting in adult female pigs and is currently undergoing clinical trials. It showed that ureteral fluorescence was dependent on ambient light and blood supply. Fluorescent signal in the plasma peaked before signal in the urine; however, it still remained high and caused background fluorescence, making it hard to see the ureter at times. According to Korb and colleagues, the ureter was always identifiable. In an oncologic setting, however, in which normal vascularity is potentially altered, this could cause significant background noise and make it difficult to identify the true ureteral course.

Other possibilities for prevention include stents and lighted stents, as in laparoscopic or robotic surgical procedures, in which tactile feedback is not possible. Currently...
there is debate regarding whether the use of preoperative ureteral stents results in any added benefit in reducing ureteral injury versus added morbidity with placement. A study by Merritt and colleagues evaluated perioperative morbidity with preoperative stent placement in 315 patients who underwent gynecologic oncology surgical procedures.\textsuperscript{11} During this study the ureteral stents were placed by gynecologists, a process that took 5 to 8 minutes on average. Only one patient was found to have a ureteral injury, and this was found postoperatively when bilateral ureterovaginal fistulas occurred. Not surprisingly, this complication was felt to be a result of the extent of the pelvic procedure and the patient’s history of pelvic radiation, rather than stent placement. Other potential complications included urinary tract infections (UTIs) in 1.48% and acute renal failure in 0.6%. Merritt and colleagues concluded that preoperative ureteral stents did not cause increased morbidity with placement and were cost-effective.

Others feel that ureteral catheterization reduces ureteral peristalsis and pliability and moves the ureter into an ectopic location, making it harder to identify.\textsuperscript{12,13} A large randomized trial by Chou and colleagues involving 3141 women undergoing major gynecologic surgical procedures showed no added benefit of prophylactic ureteral catheterization; however, severe ureteral injury was less common in patients who underwent preoperative stenting.\textsuperscript{14}

Some believe that prospective ureteral dissection and exposure can prevent future injury.\textsuperscript{15} This not only familiarizes the gynecologist with the ureteral anatomy, but in complex cases, such as oncologic procedures in which the anatomy is altered, it may provide an added benefit. However, one could argue that prospectively dissecting out the ureters routinely in all cases will prolong surgical time more than simple cystoscopy and ureteral catheter placement and could expose the ureter to potential damage, which is more likely than with simple placement of ureteral catheters.

Ureteral injury usually occurs lateral to the uterine vessels but can also occur at the uterovesical junction, near the infundibulopelvic ligament and the pelvic side wall, or where the ureter passes beneath the uterine artery\textsuperscript{16–18} (Fig. 19.2). Mechanisms of injury include crushing, ligation with a suture, transection, ischemia due to overdissection, and electrocautery injury. If not recognized intraoperatively, this can lead to renal insufficiency, chemical peritonitis due to urine leak, ileus, prolonged hospital stay, and requirement for future procedures. The average time from original operation to postoperative diagnosis of ureteral injury (if not recognized intraoperatively) is 6 to 20 days.\textsuperscript{19,20}

Risk factors for ureteral injury include previous abdominal operation, history of pelvic radiation therapy, large uterus, large tumors, infection, endometriosis, and laparoscopic techniques owing to the higher learning curve.\textsuperscript{15,21,22} Sun and colleagues studied 378 patients with advanced cervical cancer (stage IIB–IVA) who were treated with concurrent chemoradiation therapy (CCRT) (186 patients) or chemoradiation therapy plus completion surgical therapy 10 to 12 weeks after CCRT.\textsuperscript{23} Of these patients, 51.6% underwent extraperitoneal hysterectomy and 42.2% underwent radical hysterectomy. The overall rate of urinary or bowel complications was 19.8%, with 5.3% experiencing ureteral strictures. No urologic injuries were recognized intraoperatively in this study. The researchers found a higher rate of postoperative complications with radical hysterectomy than
with extravesical hysterectomy and therefore recommended radical hysterectomy only in patients with macroscopic residual tumor after CCRT.

Several other studies have found an increased rate of urologic injury during consolidation surgery, with the rate of ureteral injury reported to be as high as 11%.\textsuperscript{24–26} Laparoscopic hysterectomy has also been associated with an increase in the risk of ureteral injury, especially during the initial learning curve. One study predicted that at least 50 laparoscopic hysterectomies with lymphadenectomies are required for a surgeon to obtain adequate skills.\textsuperscript{27} A study of 317 laparoscopic radical hysterectomies and lymphadenectomies for invasive cervical cancer found that ureteral injury occurred at a rate of 1.1%; all of these injuries were unrecognized intraoperatively.\textsuperscript{28} This rate is higher than in most studies dealing with benign tumors. Because of this, the authors recommended
TABLE 19.1 Repair According to Location of Ureteral Injury

<table>
<thead>
<tr>
<th>Location</th>
<th>Type of Repair</th>
<th>What to Watch For</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper ureter</td>
<td>Ureteroureterostomy</td>
<td>May need to mobilize kidney if long distance</td>
</tr>
<tr>
<td></td>
<td>Ureterocalicystostomy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Transureteroureterostomy</td>
<td></td>
</tr>
<tr>
<td>Mid-ureter</td>
<td>Ureteroureterostomy</td>
<td>Anastomotic tension</td>
</tr>
<tr>
<td></td>
<td>Transureteroureterostomy</td>
<td>Check bladder capacity before Boari flap procedure</td>
</tr>
<tr>
<td>Distal ureter</td>
<td>Ureterocystostomy with or without psoas hitch</td>
<td>Anastomotic tension</td>
</tr>
<tr>
<td></td>
<td>Boari flap</td>
<td>Requires mobilization of bladder and possible ligation of contralateral bladder pedicle</td>
</tr>
<tr>
<td>Total ureter and extended length</td>
<td>Ileal interposition</td>
<td>Production of mucus and need for tapering with use of ileum</td>
</tr>
<tr>
<td></td>
<td>Autotransplantation</td>
<td>Possible need of vascular surgeon for autotransplantation</td>
</tr>
<tr>
<td></td>
<td>Transureteroureterostomy nephrectomy</td>
<td></td>
</tr>
</tbody>
</table>

use of the harmonic scalpel to dissect the vesicocervical ligament because it enables more precise dissection and reduces lateral thermal damage. The “click maneuver” can be useful to identify the ureter; however, this requires a hand-assisted form of surgery or an open procedure because palpation is necessary. During this maneuver, the forefinger and a right-angle instrument or another finger grasp the bladder pedicle or pillar on both sides and massage it until a click is felt, identifying the ureter.

Once suspected, the diagnosis of a ureteral injury is relatively easy, although the signs and symptoms might not be site specific. Intraoperatively, proximal hydroureteronephrosis can be a sign that the ureter has been devascularized or has been tied off or obliterated distally. Postoperatively, flank pain, abdominal pain, nausea, vomiting, fever, ileus, and leukocytosis can also be associated with a ureteral injury and possible ureteral leak. Diagnosis of these injuries intraoperatively includes flushing the ureteral stents if present to assess for possible leak or obstruction, identifying peristalsis along the ureter, and administering dyes such as indigo carmine or methylene blue to watch for ureteral efflux if cystoscopy is used. Intraoperatively, an intravenous pyelogram (IVP) examination can be performed intraoperatively by giving the patient 1 mg of intravenous contrast agent per kilogram and waiting 15 minutes before performing radiography. This test has an estimated 80% to 100% sensitivity when performed correctly. Alternatively, if access to the urethra is not possible, a controlled cystotomy can be done and ureteral catheters can be passed up the ureters to assess for obstruction. This may be a viable alternative when the patient is in the supine position, and not in lithotomy position, in which cystoscopy and ureteral catheter placement can be performed. Postoperatively, a computed tomography (CT) scan with or without contrast with delayed images (CT urogram) will enable identification of hydronephrosis to the level of obstruction; if contrast material is used, then delayed films are useful to look for a ureteral leak within the peritoneum. A retrograde pyelogram not only is a very sensitive diagnostic study for ureteral injury but also allows for treatment at the same time; however, fluoroscopy and a lithotomy position are necessary for this procedure.

Management of ureteral injuries depends on the level of injury, whether it is complete or not, and the timing of identification. Management principles require a tension-free anastomosis, preservation of viable tissue, meticulous debridement of nonviable tissue, and establishment of a low-pressure drainage system.30 Per guidelines set forth by the European Association of Urology (EAU) and the American Urological Association (AUA), upper ureteral injury (injury above the pelvic brim) can be managed with ureteroureterostomy, transureteroureterostomy, or a ureterocalycostomy.2,31 Management of mid-ureteral injuries (injury within the bony pelvis), when limited to 2 to 3 cm, includes ureteroureterostomy, transureteroureterostomy, or Boari flap reimplantation; however, adequate bladder capacity is necessary for this last procedure, because a flap of bladder is tubularized to produce the distal aspect of the ureter. For distal ureteral injuries (injury below the inferior border of the bony pelvis), options include ureteral reimplantation (ureterocystostomy) with psoas hitch as necessary to minimize tension on the anastomosis. Complete loss of the ureter or long ureteral defects will require ileal interposition, autotransplantation of the kidney, or transureteroureterostomy; however, this is best suited to occur in a delayed fashion, and in the interim a nephrostomy tube can be placed and the ureter can be tied off intraoperatively to prevent a leak. In extreme cases, a nephrectomy might be needed, but this should be done very selectively (Table 19.1). If the injury is noticed in a delayed fashion and it is a complete transection, then a stent placed in a retrograde manner will likely be unsuccessful. A nephrostomy tube can be placed, and if the urine is not adequately diverted, then placement of a periureteral drain or immediate open repair may need to occur, even in a semi-delayed fashion. Usually after 1 to 2 weeks it is very difficult to reoperate; however, if the urine cannot be diverted appropriately, this may be the only course of action. If a ureteral injury is incomplete, then placement of a ureteral stent either cystoscopically or in an antegrade fashion through nephrostomy access placed by the interventional radiology team may be performed rather than open repair, especially if noticed in a delayed fashion—that is, after more than 1 week. If it is recognized within 1 week, then a primary repair may be performed as appropriate.

**Primary Ureteral Repair**

When a ureteroureterostomy or end-to-end ureteral reanastomosis is performed, the ureter must be spatulated with Potts
scissors on both ends, on opposing sides, after all necrotic tissue has been debrided back to bleeding tissue\(^\text{29}\) (Fig. 19.3). If the ends cannot be brought together without tension, then further dissection and release of the ureter and possibly the kidney (by dissecting the kidney from the adrenal gland cranially and mobilizing it away from the psoas muscle posteriorly and the abdominal wall laterally) will be needed to bring the ureteral ends together. A 4-0 or 5-0 absorbable suture is typically placed in a running or interrupted fashion by using the full thickness of the ureter to perform the anastomosis while handling the ureter in an atraumatic fashion. If the ureter is to be directly handled, Gerald forceps may be used for handling of the ureter, and a stay-suture of Vicryl or polydioxanone (PDS) may be placed at the distal tip of each ureteral end to allow for traction. A double-J stent is then placed according to ureteral length along the anastomosis just before closure and left in place for 4 to 6 weeks to avoid obstruction and extravasation. All anastomoses should be covered with peritoneum or omentum if possible to improve healing.\(^\text{29}\) A Jackson-Pratt (JP) drain may be placed near the anastomosis, but not directly next to it, to identify any urine leak. If a urine leak is suspected postoperatively, or before JP drain removal, a JP creatinine level can be assessed (and compared with serum creatinine).

**Ureteroneocystostomy**

A ureteroneocystostomy, or ureteral reimplant, can be performed when there is a distal ureteral injury. The surgeon must decide on the approach (intravesical and extravesical) and the need for additional procedures to supplement a shortened ureter. A useful tool to check ureteral length, and therefore to create a tension-free anastomosis, is bladder distention with saline through the catheter if no cystotomy is present. If a cystotomy has been made, then an intravesical or transvesical approach can easily be performed through this opening, unless in an ectopic area, or a new cystotomy can be made along the dome for adequate visualization of the trigone. We recommend filling of the bladder first to capacity, then placing a 2-0 Vicryl stay suture (full thickness if possible) on either side of the future cystotomy. This will allow for a more controlled opening and closure of the cystotomy. Electrocautery is then used to make the cystotomy. This allows for elevation of the surrounding bladder wall and appropriate visualization of the bladder mucosa as the bladder deflates. During anastomosis, a 4-0 Vicryl suture is placed
through full-thickness ureter and then the bladder mucosal and detrusor layer. The serosal layer is closed over the anastomosis for further protection. A stent of appropriate length is placed before closure of the anastomosis, and a catheter is left within the bladder for 10 to 14 days, depending on surgeon preference, to allow for complete healing of the anastomosis and cystotomy. If there is sufficient length, then a tunneled reimplant can be performed in a 3:1 ratio of ureteral length to width within the wall to produce a nonrefluxing anastomosis (Fig. 19.4).

Tunneling requires adequate bladder wall thickness. If possible, fine Sarot or Metzenbaum scissors can be used to bluntly make the tunnel through the bladder wall by entering the adventitia and then moving inferiorly along the detrusor muscle and exiting intravesically at a determined length. An Overholt clamp is then used to grasp the stay suture at the end of the ureter and pull it through the defect; then the anastomosis can be performed intravesically. The serosal layer is then fixed to the ureteral wall with two or three delayed absorbable sutures to decrease tension. It is important to make sure the ureter is not kinked. Another option is to make the cystotomy directly through the bladder wall and then place imbricated stitches using the bladder detrusor and serosal layers to create resistance to reflux. If insufficient length is available, then a refluxing anastomosis (which is preferred) is performed with direct implantation into the dome of the bladder by using the serosa as the protective or second layer to the anastomosis as previously described (Fig. 19.4).

The use of refluxing anastomosis has not been shown to increase renal dysfunction or ureteral stenosis and is the preferred method because it is most likely to give a tension-free anastomosis. The ureter should be reimplanted along the anterior or posterior wall of the dome. Again, tension-free anastomoses are key, and a ureteral stent is placed across the new anastomosis. For insufficient ureteral length, the surgeon may need to mobilize the bladder on the contralateral side, possibly by controlling some or all of the bladder pedicle on that contralateral side, as the bladder will still retain significant collateral blood supply. This can be done with a vessel-sealing instrument or 0 or 2-0 silk suture ties, with care taken not to injure the contralateral ureter. A psoas hitch may also be required, first described by Zimmerman and colleagues. This can be performed by placing a 2-0 polyglycolic acid suture into the serosal and detrusor layer of the most cephalad portion of the bladder and then into the ipsilateral psoas muscle fascia at least 2 to 3 cm above the common iliac vessel in a vertical fashion so as not to injure the genitofemoral or femoral nerve (Fig. 19.5).

If a psoas hitch is not possible, then a Boari flap may be necessary because it can bridge up to an 8- to 10-cm defect. In this case, it is important to maximally mobilize the bladder contralaterally and test bladder capacity before forming the tubularized section of the dome that will be swung cephalad to meet the distal ureter for anastomosis. We do not recommend this procedure in patients with a previous history of radiation cystitis, poor bladder compliance, or bladder capacity below 250 mL. If a Boari flap is deemed feasible, then the bladder is first fully inflated to capacity (Fig. 19.6). The length between the bladder wall and the distal ureter is measured in order to make a tension-free anastomosis. The base of the Boari flap is located along the posterior wall, just inferior to where a direct line can be drawn from the bladder to the ureteral end. The flap is then marked out with either stay sutures or a Bovie cautery device, leaving 3 to 4 cm width for the base. The superior aspect of the flap will therefore be at the anterior bladder wall, and the length of the flap will be the same as the measured defect length, plus approximately 2 cm or more, if possible, to ensure a tension-free anastomosis.

Chapter 19 Management of Urologic Complications in Gynecologic Oncology Surgery


anastomosis. Many surgeons create a rhomboid shape with a wider base and narrower tip to accommodate for ureteral circumference. The flap is then released from the bladder on all sides except the base and tubularized and swung up to meet the ureter. For the ureteral anastomosis and tubularization, 4-0 Vicryl or delayed absorbable suture is used. A ureteral stent is then placed along the anastomosis. A drain is placed near the area of reconstruction. The ureteral stent is left in situ for 4 to 6 weeks and a Foley catheter for 10 to 14 days to allow for maximal drainage and healing. A postoperative cystogram can be obtained according to surgeon preference before removal of any catheters. Many surgeons used to delay operation to allow the inflammation to decrease after injury; however, waiting before ureteroneocystostomy is not necessary, as shown in a study by Ahn and colleagues. Although it included a small cohort of 24 patients, it demonstrated no difference between repairs within 6 weeks versus a delayed repair.

**Advanced Reconstructive Procedures**

More advanced reconstructive procedures for large ureteral defects or complete ureteral loss include procedures such as transureteroureterostomy, renal autotransplantation, and ileal substitution. Contraindications to transureteroureterostomy include inadequate donor ureter length, and disease of the recipient or donor ureter such as urothelial carcinoma, metastasis involving the ureter or ureteral fibrosis, history or presence of renal stones, and inability to achieve a tension-free anastomosis.

The recipient ureter should be mobilized sparingly to preserve blood supply, and an end-to-side anastomosis should be performed. This should be done only sparingly because of the potential for complications, quoted by the authors of one study of 63 patients to have occurred in up to 24%. Renal autotransplantation is also very rarely indicated and requires experienced transplant surgeons for harvesting and timely anastomosis of the renal unit. Ileum is by far the most commonly used organ for ureteral substitution, first popularized by Goodwin and colleagues in the 1950s (Fig. 19.7). A large retrospective study by Armatys and colleagues of 91 patients who underwent ileal-ureteral substitution for various reasons showed short-term complications of prolonged ileus and UTI. Long-term complications were anastomotic stricture (3.3%), fistula (6.6%), and worsening renal function (25.3%), although the latter cannot be directly attributed to ureteral substitution. Other uses of ileum include bladder augmentation or ileal conduit formation or continent urinary diversion (see Chapter 21). One small retrospective study by Wilkin and colleagues at the University of Wisconsin assessed the effect of pelvic radiation on continent cutaneous urinary diversions. They compared 26 patients who underwent cystectomy plus Indiana pouch continent urinary diversion after high-dose pelvic irradiation for gynecologic malignancy, versus 14 women who underwent cystectomy plus Indiana pouch continent urinary diversion without pelvic radiation for a urologic malignancy. Follow-up averaged 40 months. Significantly more complications were seen in the irradiated group than in the nonirradiated group (83% vs. 57%). More secondary procedures were required in the irradiated group, such as percutaneous nephrostomy tube placement and ureteral reimplantation, because of the higher incidence of ureteral strictures in the irradiated group, and therefore the authors concluded that long-term follow-up is
necessary for these patients for evaluation of renal function and for postoperative obstruction to be ruled out.

In well-selected cases, endoscopic and other minimally invasive procedures have shown success. Percutaneous antegrade dilation of ureteral strictures has been described with a 60% success rate, although it still is not the standard of care. Liatsikos and colleagues described a study of 10 patients with 12 obstructed renal units due to ureteral stenosis after a gynecologic surgical procedure. The mean length of stricture was 1.4 cm, and stents were removed at 1 week. Sixty percent of patients required only one dilation. Balloon dilation must be controlled because it can appropriately enlarge the lumen; however, ureteral rupture can also take place, and contrast material can act as an irritant to the retroperitoneum and instigate future fibrosis and stricture formation. Another possible treatment is the endoscopic “ureteral rendezvous,” which generally requires a radiologist and a urologist. The ureter is realigned over a guidewire and subsequently a double-J stent with the use of ureteroscopy and laparoscopy. The stent is left in place for 3 months and has shown greater than 60% success. Again, these were very small case series.

Most would agree that early repair of ureteral injuries is optimal. One study by Sakellariou and colleagues of 76 patients with iatrogenic ureteral injuries during various gynecologic operations showed that early recognition of ureteral injury was key for a successful repair. However, there are certain things that are out of the surgeon’s control, such as referral from an outside center, postoperative recovery from the initial operation, oncologic prognosis, and delay in recognition because of nonspecific symptoms and other reasons.

### Bladder Injuries and Management

Bladder injuries can cause significant morbidity owing to risk of chemical peritonitis, bacterial contamination of the peritoneum, ileus, prolonged catheterization, and risk for UTI. Bladder injuries occur at a rate of 0.2 to 19.5 per 1000 cases, with an average of 50% being recognized intraoperatively. Currently, there is debate regarding which approach presents greater risk to the bladder, but it most likely comes down to surgeon skill and preference of approach. Rates during robotic and laparoscopic procedures have been recorded as 2.4% and 1.6%, respectively. The risk for bladder injury increases with oncologic surgical procedures, because the bladder can be involved with direct tumor growth, and the tissue planes are not always well defined.

Diagnosis of bladder injury is either by direct visualization or by delayed imaging postoperatively. Intraoperatively, while a catheter is in place, the bladder can be inflated with normal saline or dyed fluid to assess for bladder injury or leak. Postoperatively, imaging studies such as a fluoroscopic cystogram or CT cystogram can be performed to assess for bladder injury. Treatment relies on location of injury and watertight closure if surgical repair is necessary. Per AUA guidelines, extraperitoneal bladder injuries, as are possibly encountered during vaginal dissections, can be managed conservatively with catheter drainage. However, if the defect is large or uncontrolled, then surgical repair should be considered. Intraoperative bladder injuries always require surgical repair in the gynecologic setting, because such injuries are usually encountered in the abdominal approach and usually lead to other sequelae that delay recovery. The bladder should be repaired in two layers with delayed absorbable suture. The first layer consists of the mucosa and detrusor layers with the use of a running stitch to reapproximate the edges. The second layer consists of the serosal layer, again closed in a running fashion. We prefer to use 3-0 Vicryl for the first layer and 2-0 Vicryl suture for the second. Once the bladder has been repaired, the catheter should remain for 1 to 2 weeks depending on surgeon preference and ease of repair but can be left for longer periods, especially in patients with large and complex bladder defects and in patients with a history of pelvic irradiation. Ideally, a cystogram should be obtained to confirm complete bladder healing before Foley removal.

### Fistula Complications

Formal diagnosis of fistulas can be performed in a clinical setting or in an operative setting. Certainly, a high level of suspicion is necessary when a patient has constant vaginal leakage or constant urinary incontinence after a history of pelvic surgery or irradiation. In the clinical setting, a pelvic examination can sometimes permit identification of large fistulas with simple palpation and appropriate lighting. For smaller fistulas, or those not purely from the bladder, further studies such as the “tampon test” or “three-sponge test” can be performed. During these tests methane blue or indigo carmine is placed within the bladder by using a Foley catheter, with (tampon test) or without (three-sponge test) the use of oral Pyridium (phenazopyridine) to stain the ureteral urine before it enters the bladder. During the sponge test, three folded gauzes or sponges are placed into the vagina one at a time, with a string attached to each for easy removal. Discoloration of the top swab with dye confirms a vesicovaginal fistula. Simple wetting (no dye coloration) of the top swab raises concern for a ureterovaginal fistula. Discoloration of the lowest swab indicates either introital backflow or a urethral fistula. These tests are not definitive, do not give exact location, and can be cumbersome, specifically in the case of the tampon test, in which it is necessary to await ureteral excretion of Pyridium to assess for a ureterovaginal fistula. Instead, most surgeons simply perform thorough examinations with the patient under anesthesia, when cystoscopy, vaginoscopy, and retrograde pyelograms can be performed without patient discomfort or time constraints. This would also allow for biopsy of the fistulous tract if malignant involvement is suspected.

Timing of fistula repair can be controversial. Classically, most surgeons would wait 3 to 6 months for tissue edema and inflammation to decrease before making an attempt at repair; however, this paradigm is changing. Surgically induced fistulas seem to have a different time course and natural history than radiation-induced fistulas. Surgically induced fistulas tend to manifest earlier and have less tissue change over time. Commonly, conservative management is attempted first, such as catheter drainage for several weeks for small fistulas. Other minimally invasive procedures such as fibrin glue injection into the fistulous tract have been shown to be effective; however, these series are small. Most authors agree that for radiation-induced vesicovaginal fistulas, delayed repair is more optimal. For surgically induced fistulas, usually a delay is not necessary and early repair can be undertaken with good results.

Similar to timing of surgical intervention, the surgical approach to fistula repair is also controversial. Important variables to consider before operation are size and location of the fistula and preferences and experience of the surgeon. It is often clear that the best chance for success is the first attempt at repair. Assuming that conservative measures have failed and that
endoscopic procedures are not attempted, surgical reconstruction will need to be planned thoroughly. The size of the fistula may necessitate a flap, and so location and ease of flap mobilization will need to be studied well and potentially planned with assistance from plastic surgery providers. On the other hand, if the size is so large that primary closure is unlikely, then urinary diversion will need to be discussed with the patient. For small fistulas, vascular flaps are usually not necessary, but are preferable as long as adequate tissue mobilization is possible. The location of the fistula is also important. A ureterovaginal fistula will necessitate an abdominal approach, unlike a vesicovaginal fistula, which can be approached either abdominally or vaginally. Location of the fistula within the bladder is also relevant; supratrigonal fistulas are usually approached abdominally. The choice of a laparoscopic versus robotic versus open approach is based on etiology of the fistula, surgeon skill, ease of identifying the fistula, and patient preference.

The principles of fistula repair are excision of all scar tissue, separation of vaginal and bladder layers, closure of the fistula with nonoverlapping absorbable suture lines, and the use of a flap whenever possible to assist with vascularity, healing, and closure of dead space. \(^{47,54}\) The bladder should be closed in two layers if possible; however, there may be a lack of available tissue owing to surrounding fibrosis. In this case, a tissue flap would be appropriate. If the ureteral orifices are encountered during fistula excision, it may be prudent to place open-ended ureteral catheters to avoid injury to the ureter, and, if needed, a double-J stent can be placed at the end of the case to prevent obstruction due to injury or surrounding edema. Tissue flaps such as the Martius flap and omental flap are optimal and provide bulk to close the dead space, healthy vascularity to the healing area, and, most important, separation of tissues. The Martius flap, described by Martius in 1928, can rely on blood supply from either the epigastric vessels (ventral) or the pudendal vessel (dorsal), depending on the method of harvesting, and is tunneled under the labia majora into the vagina. \(^{58}\) The omental flap, most commonly used in abdominal reconstruction, relies on the left gastroepiploic vessel and its tributaries for its blood supply and can reach deep into the pelvis if needed. \(^{47}\) Other possible flaps include rectus muscle, which can be used to fill large defects in the pelvis, and peritoneal flaps.

Pelvic radiation is the most common cause of delayed vesicovaginal fistula formation; the majority of these fistulas form 1.5 to 2 years after completion of therapy. \(^{57}\) Typical findings include hematuria, and areas of ulceration and necrosis along the bladder wall. Proper workup includes a urinalysis, cystoscopy to evaluate location, determination of the size of the fistula, and possible biopsy if needed to rule out neoplasms recurrence. \(^{54}\) Cystoscopy can also be used to evaluate bladder capacity and compliance. If further studies of this nature are needed, then urodynamic evaluation must be performed to ensure adequate bladder capacity and lack of alternate bladder pathologic conditions before reconstruction. This would especially be important for a patient with lower urinary tract symptoms such as urinary urgency, frequency, radiation cystitis, or chronic pelvic pain. It is also important to evaluate the upper tracts with either retrograde pyelogram or delayed imaging to confirm the absence of ureteral involvement of the fistula. Pushkar and colleagues reported on 216 patients who had radiation-induced vesicovaginal fistulas ranging from 1 to 2.5 cm that manifested in a delayed fashion, along with their management and outcomes. \(^{53}\) Reconstruction was performed in a delayed fashion an average of 14.8 months after fistula discovery. Reconstructive procedures included Latzko colpocleisis in 35.7%, vaginal repair with Martius flap in 41%, abdominal approach with omental flap in 2.8%, and primary vaginal repair without flap in 20.5%. The overall success rate of these procedures was 48.1% after one operation and 66.6% after two attempts. By the end of the follow-up period, 80.4% of patients had been treated successfully; however, 35% of these women required at least three attempts at closure for success. The authors concluded that delayed reconstruction is the best course of action for radiation-induced vesicovaginal fistulas, at approximately 12 months, owing to the propensity for the fistula to change over time and the spread of fibrosis. Even though only half of the cohort was cured after the first attempt, second and third attempts did not decrease the chances of a successful closure.

Radiation therapy leads not only to fistula formation, but other urologic morbidities as well, such as severe lower urinary tract symptoms, hemorrhagic cystitis, and ureteral stenosis. A large retrospective study by Guo and colleagues evaluated 621 patients with International Federation of Gynecology and Obstetrics (FIGO) stage IIB cervical carcinoma treated either with neoadjuvant chemotherapy and radical hysterectomy or with chemoradiation therapy to their primary tumor. \(^{59}\) These researchers found that chemoradiation therapy led to significantly more urinary complications (21.9 vs. 8.5%). The majority of these complications were radiation cystitis; however, urinary incontinence and ureteral obstruction were also seen. Of patients in the chemoradiation group, 9.1% required nephrostomy tube placement because of pelvic fibrosis. One large retrospective study from Austria of 10,709 patients who underwent curative radiotherapy for primary gynecologic malignancies found late urologic complications in 1.24% of the included patients. \(^{60}\) The majority had radiation cystitis (0.61% [65 patients]), ureteral stenosis (0.31% [33 patients]), and urinary fistula (0.33% [35 patients]). Of these patients, 88.7% required surgical intervention. Radiation may be curative for gynecologic malignancy, but associated morbidity must be considered when discussing treatment options with patients, especially when other effective treatment options are available.

**Neurogenic Bladder**

Bladder dysfunction can occur in up to 72% of women after radical hysterectomy for oncologic disease. This is thought to be due to interruption of autonomic nerve fibers innervating the bladder. \(^{61-65}\) Patients most commonly have nonobstructive urinary retention, but they may also have detrusor overactivity and poor bladder compliance. The autonomic nervous system structures encountered during dissection include the hypogastric nerves at the uterosacral ligament, pelvic splanchnic nerves along the internal iliac lymph node chain, vesical lymph nodes and associated branches of the pelvic plexus at the vesicouterine ligament, and uterosacral and rectovaginal ligaments \(^{61}\) (Fig. 19.8). The pelvic plexus and its branches have been shown to be the most important set of nerves to save during nerve-sparing radical hysterectomy (NSRH). There are several surgical techniques for NSRH, but the main objective is exposure of the hypogastric and pelvic plexus nerves to prevent undue injury while still performing the appropriate oncologic procedure. \(^{61-65}\) In a large randomized trial, 92 patients with stage IA2 and IIA cervical cancer were randomly assigned to undergo either NSRH or conventional radical hysterectomy (CRH). \(^{63}\) Urodynamic studies
were performed before operation and 1, 3, and 12 months post-operatively. Results showed that an elevated urinary residual volume and poor bladder compliance were significantly more common at 12 months in the CRH group and that all urodynamic study parameters had returned to normal at the 3-month mark in the NSRH group. Also, there was no difference in 10-year disease-free survival between groups, demonstrating that NSRH is a safe oncologic procedure. Several retrospective studies have mirrored these results.

Treatment of a patient with neurogenic bladder is dependent on the type of bladder dysfunction. Appropriate workup is necessary, including cystoscopy, postvoid residual assessment, renal imaging, and urodynamic testing to fully assess the situation. These patients should be referred to urologic specialists for further treatment. Consequences of neurogenic bladder if left untreated include calculus disease, recurrent UTIs, hydrenephrosis, vesicoureteral reflux, bladder cancer, sexual dysfunction, and eventual renal failure.
**Conclusion**

Gynecologic oncologic patients have a higher risk for urologic injury and dysfunction because of the nature and extent of the disease and the proximity of the urologic organs. It is important to preoperatively assess patients who are at risk for increased risk of urologic injury or involvement in order to maintain a high suspicion for intraoperative injuries. Preoperative and intraoperative consultation with urology colleagues should be sought whenever necessary.

Many surgical complications can be repaired intraoperatively or in the early postoperative period if recognized soon enough. Endoscopic approaches can be attempted when appropriate, but for major injuries, surgical intervention will likely be required (open, laparoscopic, or robotic, based on individual cases). Radiation has delayed effects on the urinary system. Appropriate preparation are important for planning an irradiated individual cases. Radiation has delayed effects on the urinary system. Appropriate preparation are important for planning an irradiated individual cases. Preoperative and intraoperative consultation with urology colleagues should be sought whenever necessary.

Many surgical complications can be repaired intraoperatively or in the early postoperative period if recognized soon enough. Endoscopic approaches can be attempted when appropriate, but for major injuries, surgical intervention will likely be required (open, laparoscopic, or robotic, based on individual cases). Radiation has delayed effects on the urinary system. Appropriate preparation are important for planning an irradiated individual cases. Preoperative and intraoperative consultation with urology colleagues should be sought whenever necessary.

Many surgical complications can be repaired intraoperatively or in the early postoperative period if recognized soon enough. Endoscopic approaches can be attempted when appropriate, but for major injuries, surgical intervention will likely be required (open, laparoscopic, or robotic, based on individual cases). Radiation has delayed effects on the urinary system. Appropriate preparation are important for planning an irradiated individual cases. Preoperative and intraoperative consultation with urology colleagues should be sought whenever necessary.

Many surgical complications can be repaired intraoperatively or in the early postoperative period if recognized soon enough. Endoscopic approaches can be attempted when appropriate, but for major injuries, surgical intervention will likely be required (open, laparoscopic, or robotic, based on individual cases). Radiation has delayed effects on the urinary system. Appropriate preparation are important for planning an irradiated individual cases. Preoperative and intraoperative consultation with urology colleagues should be sought whenever necessary.

Many surgical complications can be repaired intraoperatively or in the early postoperative period if recognized soon enough. Endoscopic approaches can be attempted when appropriate, but for major injuries, surgical intervention will likely be required (open, laparoscopic, or robotic, based on individual cases). Radiation has delayed effects on the urinary system. Appropriate preparation are important for planning an irradiated individual cases. Preoperative and intraoperative consultation with urology colleagues should be sought whenever necessary.

Many surgical complications can be repaired intraoperatively or in the early postoperative period if recognized soon enough. Endoscopic approaches can be attempted when appropriate, but for major injuries, surgical intervention will likely be required (open, laparoscopic, or robotic, based on individual cases). Radiation has delayed effects on the urinary system. Appropriate preparation are important for planning an irradiated individual cases. Preoperative and intraoperative consultation with urology colleagues should be sought whenever necessary.

Many surgical complications can be repaired intraoperatively or in the early postoperative period if recognized soon enough. Endoscopic approaches can be attempted when appropriate, but for major injuries, surgical intervention will likely be required (open, laparoscopic, or robotic, based on individual cases). Radiation has delayed effects on the urinary system. Appropriate preparation are important for planning an irradiated individual cases. Preoperative and intraoperative consultation with urology colleagues should be sought whenever necessary.

Many surgical complications can be repaired intraoperatively or in the early postoperative period if recognized soon enough. Endoscopic approaches can be attempted when appropriate, but for major injuries, surgical intervention will likely be required (open, laparoscopic, or robotic, based on individual cases). Radiation has delayed effects on the urinary system. Appropriate preparation are important for planning an irradiated individual cases. Preoperative and intraoperative consultation with urology colleagues should be sought whenever necessary.

Many surgical complications can be repaired intraoperatively or in the early postoperative period if recognized soon enough. Endoscopic approaches can be attempted when appropriate, but for major injuries, surgical intervention will likely be required (open, laparoscopic, or robotic, based on individual cases). Radiation has delayed effects on the urinary system. Appropriate preparation are important for planning an irradiated individual cases. Preoperative and intraoperative consultation with urology colleagues should be sought whenever necessary.

Many surgical complications can be repaired intraoperatively or in the early postoperative period if recognized soon enough. Endoscopic approaches can be attempted when appropriate, but for major injuries, surgical intervention will likely be required (open, laparoscopic, or robotic, based on individual cases). Radiation has delayed effects on the urinary system. Appropriate preparation are important for planning an irradiated individual cases. Preoperative and intraoperative consultation with urology colleagues should be sought whenever necessary.

Many surgical complications can be repaired intraoperatively or in the early postoperative period if recognized soon enough. Endoscopic approaches can be attempted when appropriate, but for major injuries, surgical intervention will likely be required (open, laparoscopic, or robotic, based on individual cases). Radiation has delayed effects on the urinary system. Appropriate preparation are important for planning an irradiated individual cases. Preoperative and intraoperative consultation with urology colleagues should be sought whenever necessary.

Many surgical complications can be repaired intraoperatively or in the early postoperative period if recognized soon enough. Endoscopic approaches can be attempted when appropriate, but for major injuries, surgical intervention will likely be required (open, laparoscopic, or robotic, based on individual cases). Radiation has delayed effects on the urinary system. Appropriate preparation are important for planning an irradiated individual cases. Preoperative and intraoperative consultation with urology colleagues should be sought whenever necessary.

Many surgical complications can be repaired intraoperatively or in the early postoperative period if recognized soon enough. Endoscopic approaches can be attempted when appropriate, but for major injuries, surgical intervention will likely be required (open, laparoscopic, or robotic, based on individual cases). Radiation has delayed effects on the urinary system. Appropriate preparation are important for planning an irradiated individual cases. Preoperative and intraoperative consultation with urology colleagues should be sought whenever necessary.

Many surgical complications can be repaired intraoperatively or in the early postoperative period if recognized soon enough. Endoscopic approaches can be attempted when appropriate, but for major injuries, surgical intervention will likely be required (open, laparoscopic, or robotic, based on individual cases). Radiation has delayed effects on the urinary system. Appropriate preparation are important for planning an irradiated individual cases. Preoperative and intraoperative consultation with urology colleagues should be sought whenever necessary.

Many surgical complications can be repaired intraoperatively or in the early postoperative period if recognized soon enough. Endoscopic approaches can be attempted when appropriate, but for major injuries, surgical intervention will likely be required (open, laparoscopic, or robotic, based on individual cases). Radiation has delayed effects on the urinary system. Appropriate preparation are important for planning an irradiated individual cases. Preoperative and intraoperative consultation with urology colleagues should be sought whenever necessary.

Many surgical complications can be repaired intraoperatively or in the early postoperative period if recognized soon enough. Endoscopic approaches can be attempted when appropriate, but for major injuries, surgical intervention will likely be required (open, laparoscopic, or robotic, based on individual cases). Radiation has delayed effects on the urinary system. Appropriate preparation are important for planning an irradiated individual cases. Preoperative and intraoperative consultation with urology colleagues should be sought whenever necessary.

Many surgical complications can be repaired intraoperatively or in the early postoperative period if recognized soon enough. Endoscopic approaches can be attempted when appropriate, but for major injuries, surgical intervention will likely be required (open, laparoscopic, or robotic, based on individual cases). Radiation has delayed effects on the urinary system. Appropriate preparation are important for planning an irradiated individual cases. Preoperative and intraoperative consultation with urology colleagues should be sought whenever necessary.

Many surgical complications can be repaired intraoperatively or in the early postoperative period if recognized soon enough. Endoscopic approaches can be attempted when appropriate, but for major injuries, surgical intervention will likely be required (open, laparoscopic, or robotic, based on individual cases). Radiation has delayed effects on the urinary system. Appropriate preparation are important for planning an irradiated individual cases. Preoperative and intraoperative consultation with urology colleagues should be sought whenever necessary.
We restore, repair and make whole those parts … Which nature has given but which fortune has taken away.
GASPAR TAGLIACOZZI (1545–1599)

The goals of pelvic and perineal reconstruction in gynecologic oncology surgery may be summarized as follows:
- Maximize wound healing, with adequate dead space obliteration, to hasten recovery before and after chemotherapy and radiation therapy
- Preserve function, including intestinal and urinary integrity, as well as sexual performance
- Minimize deformity and morbidity, both physically and psychologically

One must also consider whether the extirpative surgery is for curative intent or palliation, because this may change the goals of reconstruction. Reconstruction may include perineal closure, vulvovaginal reconstruction, and abdominal wall reconstruction.¹,²

Indications
Preoperative Evaluation and Patient Selection
All patients undergoing pelvic resection should be offered a preoperative reconstructive evaluation. This serves both to answer patient questions regarding expectations and also to customize the reconstruction according to each patient’s particular needs. Some of the challenges in obtaining a successful reconstruction may include:
- Adverse effects of neoadjuvant versus adjuvant therapies, including chemotherapy and radiation
- Presence of patient morbidities, including but not limited to diabetes, smoking, obesity, prior surgeries, and malnutrition
- Iatrogenic impairments, including edema and lymphedema, wound tension, and poor perfusion of tissues

Preoperative planning, when possible, helps to minimize associated morbidities of reconstruction. Factors to be considered in the planning of a reconstruction may include:
- Size, volume, and location of defect
- Patient’s ability or inability to heal
- Availability of potential donor sites
- Ease of donor site closure (skin, fascial levels)
- Flap pedicle viability
- Location of perforators to skin (for flap design)

Procedures
Secondary Intention and Complex Primary Closure
As mechanisms of healing, both secondary intention and complex primary closure are among the simpler ways to achieve perineal closure. Secondary intention allows a patient to be treated with local wound care, to better allow her innate mechanisms of healing to work. Complex closure involves wide undermining of the remaining soft tissues to allow for a tension-free closure in layers. This technique may be useful for small partial vaginectomies, vulvectomies, or perineal resections (Fig. 20.1).

Procedure Details
Skin hooks are used to retract the soft tissues; the electrocautery device is used to elevate the subcutaneous fat off the deeper fascia. Perforating blood vessels should be maintained, unless they limit skin advance and therefore must be ligated and divided. The soft tissues are suture approximated in layers, taking tension off the final closure.

Skin Grafting and Skin Substitutes
Skin grafts may be harvested as split or full thicknesses of dermis. The former may be harvested in larger sizes, but the latter tend to contract less with time. In either circumstance, skin grafts require a well-vascularized wound bed for survival. Bolstering a skin graft may enhance its take in the first days after placement. However, appropriate bolsters may be difficult to achieve in the perineal region, especially because of the flow of urine and/or stool.

Skin substitutes have become commonplace in reconstructive surgery. They are often derived as acellular matrices from dermis or other organ systems, from both human and animal sources. They may aid in coverage in these challenging areas, where skin grafts are less likely to survive.
Section 9 Pelvic Reconstructive Procedures

Procedure Details

Full-thickness skin grafts are harvested from any area of the body where the donor site may be closed primarily. A template is marked, and the area is infiltrated with epinephrine-containing local anesthetic. The graft is harvested by using a No. 10 blade. The donor site is widely undermined if necessary to reduce tension and is closed in layers. The graft is further prepared by removing subcutaneous fat from the dermal side with curved Iris scissors. “Pie-crusting” (placing fenestrations in graft to allow for egress or fluid buildup) is performed with a No. 15 blade. The graft is placed dermis side down on the wound bed and secured in place with staples or absorbable sutures. A bolster dressing is then applied. A split-thickness skin graft (STSG) may be obtained by using a powered dermatome and similarly placed onto a wound. However, the donor site for an STSG may be less cosmetically appealing. Skin substitutes have no donor site but may behave like foreign bodies until fully integrated.

Local Flaps

Local flaps are tissues that can be advanced or rotated from their starting positions while remaining connected to a sufficient blood supply. Because local tissues tend to have the greatest similarity with their resected counterparts, it is best to follow the adage “When possible, replace like with like.” Local flaps take advantage of the inherent laxity of nearby tissues, which allows for mobilization with primary closure of the donor site. There are a variety of well-described local flaps for the perineal region. Two commonly used flaps are the Singapore flap and the V-to-Y advancement flap.

The Singapore flap, also known as the pudendal flap, may be based anteriorly or posteriorly. A full thickness of tissue (skin, subcutaneous fat, and fascia) is elevated to maximize perfusion. Although they can be designed as random pattern flaps (i.e., based on dermal blood supply), axial flaps based on the pudendal vessels (included with the deeper fascia) tend to have better perfusion. These flaps can be harvested unilaterally or bilaterally and are effective for partial vaginal and/or vulvar reconstructions (Fig. 20.2).

Procedure Details

Markings are made lateral to the vulva in the area of the proximal medial thigh. Local anesthetic may be used. Incisions are made with scalpel and electrocautery down through the fascia. The base of the flap is elevated such that flap rotation may be sufficient to reach the full extent of the defect. Wide undermining of the donor site is performed to reduce tension on primary layered closure. The flap is sutured in multiple layers to its recipient site.

V-to-Y advancement allows local tissues to be approximated while perfusion is maintained via centrally based perforating vessels. The greatest advancement is achieved by incising a full thickness of skin, fat, and fascia but with only enough undermining that the central perforators are still maintained. The V-to-Y design allows for primary closure of the donor site. Depending on the size and location of the defect, V-to-Y advancement flaps can be performed in either the lithotomy or jackknife prone positions (Fig. 20.3).
Procedure Details

Markings are made for sufficiently large triangular flaps extending the entire length of the wound. Incisions are made with a scalpel and electrocautery, through the deep fascia. The flaps are advanced medially, undermining with electrocautery only as much as necessary to achieve the required advancement without completely separating the flaps from the deeper tissues. The flaps are secured together in the midline, and the donor sites are closed primarily and to the flaps, such that the final scar is a Y rather than a V.

Regional Flaps: Abdomen

Vertical Rectus Abdominis Myocutaneous Flap

The most common flap harvested from the abdominal wall is the vertical rectus abdominis myocutaneous (VRAM) flap. The rectus abdominis muscle has a type III Mathes and Nahai vascular supply, meaning dominant perfusion from both the superior and the deep inferior epigastric vessels. Ligation of the superior epigastric system allows the muscle flap to remain sufficiently

FIG. 20.2 A 55-year-old woman with vulvar carcinoma, undergoing wide excision with left Singapore flap reconstruction and right complex closure. (A) Intraoperative defect with flap design. (B and C) inset of flap with closure of donor site. (D–F) Postoperative healing.
perfused by the deep inferior system alone, which is critical for pelvic reconstruction. Benefits of the VRAM flap for pelvic and perineal reconstruction include composite tissue possibilities (skin, fat, fascia, muscle, peritoneum), large bulk or size, long pedicle length, robust perfusion, and usually acceptable donor site morbidity.4–7

Disadvantages of VRAM use are mostly related to its potential donor site morbidity, which may include abdominal wall weakness, bulging, or hernia and delayed wound healing. Weakness may be minimized by preserving the rectus muscle and its lateral intercostal innervation by harvesting a muscle-sparing flap. Such a maneuver is of greater importance in patients undergoing bilateral VRAM flap harvest, which is rare (but common with bilateral transverse rectus abdominis myocutaneous [TRAM] flap breast reconstruction). Often, however, the rectus muscle is an important component of the flap, useful for different aspects of pelvic reconstruction, and is therefore usually fully harvested. Other procedures may then be performed to minimize abdominal wall morbidity, including component separation and mesh reinforcement.

The only firm contraindication to VRAM harvest includes prior flap harvest. Relative contraindications may include ostomy presence; subcutaneous tissues previously elevated off muscle (destroying the perforator anatomy and therefore perfusion to the subcutaneous tissues); presence of large ventral hernia or history of previous hernia repair; deep inferior epigastric artery perforator (DIEP) flap harvest for breast reconstruction; and prior liposuction (which may decrease flap bulk or injure perforators).

Abdominal closure may be tensioned after flap harvest or even secondary to edema from prolonged operation or significant intravenous fluid administration. Closing the abdomen under tension can lead to significant morbidity, including ischemia and poor wound healing, delay in administration of adjuvant therapies, herniation of abdominal contents, and diminishment of quality of life (despite cancer cure). Medical comorbidities (e.g., smoking and diabetes), lymphedema, chemotherapy, radiation, infection, and malnutrition may all lead to poor wound healing. In addition, portions of the abdominal wall may require resection as part of the cancer operation, leading to additional tension with primary closure. If primary, non-tensioned abdominal wall closure is not possible, the following steps may be considered:

At the skin level: secondary intention (with or without wound vacuum-assisted closure [VAC]); delayed primary closure; local or regional flap (e.g., large adjacent tissue rearrangement, pedicled anterolateral thigh [ALT] flap); free flap

At the myofascial level: mesh (synthetic or bioprosthesis) for reinforcement or bridged repair; component separation8,9 (Fig. 20.4)

Ideally, VRAM flap design will be adjusted in consideration of donor site closure, to minimize these morbidities. Adjustments may include muscle- and/or fascial-sparing harvest, minimally invasive harvest, minimal-tension closures with component separations, and perforator-sparing harvest.10,11

---

**FIG. 20.3** An 84-year-old woman with recurrent vulvar carcinoma in previously irradiated field. The patient underwent abdominoperineal resection with permanent colostomy and pedicled omental flap for pelvic dead space obliteration but with a large perineal defect. Reconstruction with V-to-Y fasciocutaneous advancement flaps was performed. (A) Intraoperative defect. (B) Design of V-to-Y flaps. (C) Flap inset with primary closure of donor sites.
Pearl: Ways to Spare Fascia During Vertical Rectus Abdominis Myocutaneous Flap Harvest

Enter the peritoneum via a paramedian fasciotomy, near medial row perforators, instead of through the linea alba. Continue elevating the flap from lateral to medial, and include only the minimal amount of fascia needed to harvest essential perforators. Use a zigzag approach to fasciotomy as needed. Preoperative computed tomography (CT) assessment can be helpful to locate perforators (CT imaging performed for cancer surveillance is usually sufficient and obviates the need for dedicated CT angiograms) (Fig. 20.5).

Pearl: Raising Vertical Rectus Abdominis Myocutaneous Flap

Make a periumbilical incision on the same side as the VRAM, to keep the umbilicus with the abdomen and retain a sufficient blood supply to it. Harvest the skin paddle over the entirety of the rectus muscle, and de-epithelialize the proximal (inferior) portions that are not needed for external use (this will capture additional perforators and add bulk for dead space obliteration of the pelvis). Only disinsert muscle from the pelvis if additional length is needed, to minimize tension on the vascular pedicle on the flap inset. It is always better to have too much tissue (which can be debulked later) than too little tissue.
Pearl: Variations of Vertical Rectus Abdominis Myocutaneous Flap

Rectus Abdominis Muscle–Only Flap
A rectus abdominis muscle–only flap can be useful for a partial vaginectomy defect only or when minimal pelvic dead space is to be obliterated (more common in the male than the female pelvis). This flap may be used in combination with an omental flap (unless omentectomy has already been performed). It leaves the rectus fascia intact to facilitate closure of the abdomen and may be useful in obese patients with an otherwise thick skin paddle, with or without a skin graft.

Rectus Abdominis Muscle With Peritoneum
The peritoneal lining may enable mucosal-like reconstruction for a partial vaginectomy defect. This variation is especially useful if the adipose component of the skin paddle is too thick (e.g., in an obese patient) and therefore is best avoided for reconstruction. Limitations include a lack of flap volume and therefore minimal dead-space obliteration (Fig. 20.6).

Extended Vertical Rectus Abdominis Myocutaneous Flap
The extended vertical rectus abdominis myocutaneous (eVRAM) flap is useful to obtain additional skin and fat with the distal (superior) flap for pelvic or perineal reconstruction. The eVRAM flap requires sufficient laxity of the abdominal wall for donor site closure. It is useful for tubed flaps (e.g., total vaginal reconstruction), large perineal defects requiring additional skin coverage, and increased bulk in thin patients (Fig. 20.7).

FIG. 20.5 Computed tomography angiogram (axial cut) of the abdomen. Arrow points to an abdominal wall perforator emanating from the deep inferior epigastric vessels within the rectus abdominis muscle. Such preoperative images are useful in planning flaps that maximize perfusion while minimizing morbidity.

FIG. 20.6 A 57-year-old woman with advanced colorectal carcinoma requiring abdominoperineal resection with end colostomy. Posterior vaginectomy was reconstructed with pedicled rectus abdominis flap. Attached peritoneal lining used to replace posterior vaginal mucosa. (A) Anterior surface of harvested rectus muscle flap. (B) Posterior surface of harvested rectus muscle flap with attached peritoneal lining. (C) Flap inset to posterior vaginectomy defect before perineal closure.
FIG. 20.7 A 61-year-old woman with recurrent uterine cancer undergoing pelvic exenteration. Extended vertical rectus abdominis myocutaneous (eVRAM) flap procedure was performed for total vaginal reconstruction and dead space obliteration. (A–C) Preoperative abdomen and eVRAM markings. (D–F) Intraoperative harvest, tubing, and deepithelialization of eVRAM flap. (G) Postoperative abdominal wall with presence of ostomies but no hernia or bulge. (H and I) Postoperative vaginal reconstruction.
Closure of Vertical Rectus Abdominis Myocutaneous Flap Donor Site

If sufficient laxity of the abdominal wall fascia is present, primary closure can be performed. Excessive tension should be avoided, to minimize the risk of incisional hernia. Fascial-sparing VRAM harvest may also be performed, particularly when no prior midline laparotomy scar is present. If the fascial closure is tensioned, component separation can be performed after VRAM harvest, with or without reinforcement with mesh (bioprosthetic or synthetic). One may also consider bioprosthetic reinforcement around ostomies to minimize parastomal hernia formation.

For minimally invasive procedures, if laparoscopy or a robotic system is used for resection, the harvest of a rectus flap can still be performed. A VRAM or eVRAM flap can be harvested in the usual manner. A small midline fascial incision is made just above the pubis to insert the flap into the pelvis. Furthermore, the robotic system has been used to successfully harvest rectus muscle flaps, although this is usually a variant without the skin paddle and therefore is of limited use in gynecologic oncologic reconstruction.1

Procedure Details

Through the open midline abdominal incision, the medial edge of the rectus abdominis muscle should be visible. Make lateral incisions with scalpel and electrocautery. Dissect along the rectus fascia medially until the most medial perforators are visualized. An additional fasciotomy can be made just lateral to these perforators. Place Allis clamps on the lateral edge of the fascia, and elevate the muscle from the sheath with electrocautery. At the costal margin, separate the muscle from the ribs using electrocautery, and ligate the superior epigastric vessels with clips. Mobilize the flap from the rectus sheath from cranial to caudal, ligating the intercostal neurovascular bundles while proceeding. Take care to visualize and protect the deep inferior epigastric vascular pedicle during this process. Leave the muscle inserted onto the pubis to reduce tension on the vascular pedicle to the flap. The flap may be rotated down into the pelvis, and the donor site closed after bringing through any necessary ostomies.

Omental Flap

The omental flap may provide well-vascularized tissue and sufficient bulk for pelvic dead space obliteration. Bulk is greater in obese patients, in whom use of a VRAM flap may provide significant morbidity. The omentum may be pedicled on either the left or the right gastroepiploic vessels. A skin graft may be successfully placed on the omental flap, which is a useful method for partial vaginectomy reconstruction (Fig. 20.8). Unfortunately, in many gynecologic oncology patients, omentectomy is performed as part of the initial surgical staging, and the omentum is therefore unavailable for further use in reconstruction.

Procedure Details

The omentum should be freed from visceral attachments. One gastroepiploic pedicle should be maintained and the other ligated and divided. Once sufficient release of the omentum has been achieved, it can be placed into the pelvis. Any poorly perfused portions should be resected before the final inset.

FIG. 20.8 A 72-year-old woman with gastrointestinal stromal tumor (GIST) of posterior vaginal wall near rectum. Resection with pedicled omental flap interposition was performed to minimize fistula formation. Posterior vaginal wall was reconstructed with full-thickness skin graft to omentum. (A) Posterior vaginectomy specimen. (B) Inset of omental flap. (C) Inset of full-thickness skin graft.
Regional Flaps: Thigh and Buttock

Gracilis Flap
Based on the pudendal vessels, the gracilis muscle of the medial thigh can be harvested as a muscle-only or myocutaneous flap.\textsuperscript{14,15} It is useful in partial vaginal reconstruction, or even total vaginal reconstruction if bilateral flaps are used (Fig. 20.9). Disadvantages include small muscle volume (bulk), poor reliability of skin paddle perfusion (due to lack of direct perforators), and limited excursion of the flap into the pelvis due to pedicle length.

Procedure Details
With the patient in the lithotomy position, the gracilis muscle is marked along the medial thigh. It originates at the pubic symphysis, inferior pubic ramus, and ischium and extends distally into the medial condyle of the knee. With palpation of the adductor longus muscle, the gracilis should be two to three fingerbreadths posterior. A single incision or two smaller incisions are made along the length to identify the proximal and distal components. The neurovascular pedicle is identified approximately 10 cm below the ischium, and this is the pivot point for a pedicled flap.

The transverse upper gracilis (TUG) flap is a variation in which the skin paddle is proximally based and transverse rather than longitudinal along the muscle. Primarily used as a free flap for breast reconstruction, it may also be used as a pedicled flap for pelvic or perineal reconstruction.

The profunda artery perforator (PAP) flap is a fasciocutaneous flap from the proximal posteros medial thigh that spares the gracilis muscle. Its use in pelvic reconstruction is limited by pedicle length, but it may be useful for perineal coverage in the appropriate patient.

Anterolateral Thigh Flap
Use of the ALT or vastus lateralis flap has become routine in reconstructive procedures owing to its long pedicle (descending branch of lateral circumflex femoral vessels), consistent perforator anatomy, large amount of well-perfused tissue that can be harvested, and minimal donor site morbidity.\textsuperscript{16,17} The ALT flap may be harvested as a fasciocutaneous, myofasciocutaneous, or chimeric flap with multiple components. This flap is especially useful when abdominally based options are neither sufficient nor available, and it has greater usefulness and reliability than the gracilis flap for pelvic reconstruction.\textsuperscript{18} In most cases the donor site is closed primarily, but it may be skin grafted if there is significant tension. As a pedicled flap, it may be rotated across the inguinal ligament into the pelvis, or instead brought through a perineal approach. If pedicle length is limiting, the ALT flap may be easily converted to a free flap. This is accomplished by extending the pedicle length with a venous interposition graft or by using nearby recipient vessels (e.g., deep inferior epigastric vessels, if not already used for a VRAM flap) in a microsurgical anastomosis (Fig. 20.10).

Procedure Detail
A line is drawn on the thigh connecting the anterior superior iliac spine (ASIS) to the superolateral patella. Markings are made at the midpoint and 5 cm both proximal and distal, all 1.5 cm lateral to this line. An anterior incision is made approximately 2 cm medial to this line, and a subfascial dissection is performed over the rectus femoris muscle. Within the intermuscular septum with the vastus lateralis will be the descending branch of the lateral circumflex femoral vessels, which serves as the vascular pedicle for the flap. Perforating vessels to the skin paddle will emanate from this pedicle, either in the septum itself or within the substance of the vastus lateralis. Proximal, distal, and posterior skin paddle incisions are made. Continued elevation with only a fasciocutaneous skin paddle or with a component of the vastus lateralis muscle can be performed about the perforating vessels. Dissection of the vascular pedicle toward its origin will complete harvest of the pedicled flap, which can easily be converted to a free flap depending on various factors.

Gluteal Flaps
The most common flaps from the buttock are based off the superior gluteal artery perforator (SGAP) or inferior gluteal artery perforator (IGAP) vessels. These flaps have been described for pelvic dead space obliteration, perineal coverage, and partial vaginectomy reconstruction.\textsuperscript{19} However, use of these flaps requires a position change (prone or prone jackknife), which decreases their usefulness in primary reconstruction.

Conclusion
Pelvic reconstruction is an essential component in the care of the gynecologic oncology patient. Surgical procedures should be carefully planned and executed based on the patient’s short- and long-term goals, as well as the available donor sites. As the ability to remove larger and more complex tumors increases, so must the options in the surgeon’s reconstructive arsenal.
A 36-year-old woman with recurrent vaginal adenocarcinoma in a previously irradiated field. The patient was undergoing pelvic exenteration with bilateral internal hemipelvectomies. As part of the latter procedures, the deep inferior epigastric vascular pedicles were ligated, rendering vertical rectus abdominis myocutaneous (VRAM) flaps unavailable. Therefore, bilateral pedicled gracilis myocutaneous flaps were used for total vaginal reconstruction. (A and B) Markings for gracilis myocutaneous flap harvest. (C–E) Closure of donor sites with inset of flaps. (F) Postoperative computed tomography axial image.
FIG. 20.10 A 56-year-old woman with recurrent anal squamous cell carcinoma, with extensive local involvement. The patient was undergoing abdominoperineal resection with posterior vaginectomy. The vertical rectus abdominis myocutaneous (VRAM) flap would have provided insufficient tissue volume; therefore an anterolateral thigh (ALT) flap with vastus lateralis muscle was harvested. The vascular pedicle was too short to allow the flap to reach the pelvis; therefore the flap was converted to a free flap. The skin paddle was used for posterior vaginal reconstruction, with the remainder of the tissue used for dead space obliteration. (A–C) Harvest of ALT flap with vastus lateralis, showing vascular pedicle and anatomy of perforators to skin paddle. (D and E) Postoperative inset of skin paddle for vaginal wall reconstruction.
References


Pelvic exenteration, the most radical of pelvic procedures, is used with curative or palliative intent in the treatment of women with primary and recurrent pelvic malignancies. In women undergoing total or anterior exenterative procedures, the choice of urinary diversion can have a great impact on functional outcome, intraoperative and postoperative complications, and overall quality of life. The importance of the reconstruction phase on the psychosocial well-being of women cannot be overemphasized because it can avoid the dependence of a permanent colostomy. Over the course of 60 years, various techniques have been described for the construction of urinary diversion since ureterosigmoidostomy was first completed in the early 1900s. The unacceptable rate of retrograde fecal contamination resulting in ascending infections with recurrent pyelonephritis and subsequent loss of renal function paved the way for alternative forms of urinary reconstruction. This chapter describes the various techniques for incontinent and continent urinary diversions that have evolved throughout the years and the management of common postoperative complications.

**Historical Perspective of Urinary Diversions**

One of the first reported cases of urinary diversion was by Dr. Franklin H. Martin in 1899, who described a ureterosigmoidostomy or wet colostomy. The wet colostomy was the procedure of choice for urinary diversion during the early series of pelvic exenterations as described by Dr. Alexander Brunschwig in 1948. This procedure remained popular from 1900 through the 1950s because it was technically easy to perform and obviated the need to excise an additional and separate section of intestine such as the ileum. Bricker was the first to describe the use of an ileal conduit as an incontinent urinary reservoir as an alternative to the ureterosigmoidostomy, which had proven over time to increase the incidence of electrolyte abnormalities, hyperchloremic metabolic acidosis, urinary and fecal incontinence, recurrent upper urinary tract infections (UTIs), chronic renal insufficiency and failure, hydronephrosis, and ureteral strictureing. He reported a simple and reliable method of urinary diversion with acceptable complication rates, and as a result the ileal conduit became the most common method of diversion in gynecologic oncology. The sigmoid conduit was not reported until 20 years later by Symmonds and Gibbs; this procedure was technically easier and eliminated the necessity to perform an additional small bowel resection and anastomosis. When compared with the ileal conduit, the sigmoid conduit was found to have similar functionality, decreased operative time, and improved postoperative morbidity. Challenges arose in gynecologic oncology practice when sigmoid colon was used for conduit formation, however, because this tissue was often damaged from prior pelvic irradiation. In an attempt to further decrease the rate of conduit leaks, fistulas, and ureteral strictures, the use of the transverse colon for the formation of colonic conduits became popular.

A continent urinary diversion was first described by Gilchrist and colleagues in 1950; this procedure used a segment of cecum, with the ileocecal valve providing the continence mechanism. Subsequent reports highlighted the increase in technical difficulty, higher complication rates, and urinary incontinence resulting from cecal peristaltic hyperactivity. In 1978, Kock and colleagues introduced a continent urinary diversion in which an ileal segment of intestine with an intussuscepted nipple valve was used as the mechanism of continence, with use of a detubularized technique that provided a lower pressure system rather than a straightforward tubular component and a larger volume. The principle of interrupting the circular muscle fibers longitudinally and then folding the intestinal tubular structure to unite the proximal and distal ends, thereby decreasing the pressure gradient produced by the circular muscle contractions, has become the foundation of a low-pressure continent urinary diversion. With a failure rate of 15% to 20% with the Kock ileal pouch, new methods of urinary diversions were explored. In 1986 Thuroff and colleagues published a report describing the creation of a continent urinary diversion, or Mainz pouch, using two loops of ileum, cecum, and ascending colon. The ureters were anastomosed in a nonrefluxing submucosal tunneling technique with an isoperistaltic intussusception distal ileum as the continence mechanism. In 1984, the Indiana pouch was introduced by Rowland and associates; this procedure involved the formation of a...
right colonic reservoir by plicating the terminal ileum to reinforce the ileocecal valve. With this mechanism, an astounding daytime continence rate of 93% was achieved. Lockhart and Bejany remodeled the Indiana pouch by using the terminal ileum, cecum, and ascending and proximal transverse colon to construct the reservoir, which was folded onto itself; the ileum was plicated with two rows of permanent sutures to form the continent mechanism, allowing for a larger urinary reservoir. The authors reported that a directed nontunneled ureterointestinal implantation was another option to the intussuscepted nipple valve of the Kock pouch to achieve an antireflux ureteral mechanism. In 1989 Penalver and colleagues introduced the Miami pouch into gynecologic oncology; this procedure incorporated modifications such as the placement of the three circumferential permanent sutures in a purse-string fashion proximal to the ileocecal valve and tapering of the ileal segment over a 14F catheter. This surgical technique has become the most popular form of continent urinary diversion in gynecologic oncology.

The choice of creating a continent versus an incontinent urinary diversion in the gynecologic oncology patient requires evaluation of a number of different and important factors. First, the surgeon needs to choose a method of which he or she has knowledge—not only of the surgical technique but also of the various complications and their subsequent management. Next, a meticulous evaluation of the size, extent, and previous treatment of the tumor will help exclude specific options. A patient with either primary or recurrent tumor involving the base of the bladder or urethra will not be a candidate for an orthotopic reservoir (use of the patient’s own urethra with a segment of intestine to either augment or replace the bladder). This method

**FIG. 21.1** (A) Segment of ileum is isolated with accompanying mesentery. (B) The proximal segment of the ileum is exteriorized forming the cutaneous stoma, and bilateral ureters are anastomosis to the distal end of the ileal reservoir. (C) Drawing illustrates direct ureterostomies. (Source: Ileal Conduit Urostomy Stock Vector Illustration.)

### Indications for Urinary Diversion

Reconstruction of the lower urinary tract has been a challenge for many years. The bladder is a hollow, muscular organ that serves as a low-pressure urine storage reservoir capable of complete emptying via the urethra. Between voids, appropriate bladder capacity maintains continence. When the bladder is crippled by disease and cystectomy is performed, a urinary diversion is needed. The ideal urinary reservoir is one that achieves a low-pressure system that stores a functional amount of urine (about 500 mL), has no absorption of urinary waste products, and is able to maintain complete continence and complete voluntary control of voiding. Metabolic derangements that are encountered from urinary diversion depend on which segment of intestine is used and the specific absorptive function of that specific bowel segment. Consequently, an ideal neobladder has not been found, so any segment of bowel can be used to create a urinary diversion that is functional but may be impaired based on the location, length, intestinal disease, and previous radiation to the specific bowel segment used.

Table 21.1 reviews the different forms of urinary diversions.
TABLE 21.1 Types of Urinary Diversions

<table>
<thead>
<tr>
<th>Incontinent Diversions</th>
<th>Ureteral Anastomosis</th>
<th>Cutaneous Anastomosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ureterostomy</td>
<td>Directly to skin</td>
<td></td>
</tr>
<tr>
<td>Ureterosigmoidostomy or ureterocolostomy</td>
<td>Anastomosed to the proximal colon</td>
<td>Distal colon exits the skin</td>
</tr>
<tr>
<td>Ileal conduit</td>
<td>Anastomosed to the proximal ileum</td>
<td>Distal ileum is anastomosed to the skin</td>
</tr>
<tr>
<td>Sigmoid conduit</td>
<td>Anastomosed to the proximal sigmoid colon</td>
<td>Distal sigmoid is anastomosed to the skin</td>
</tr>
<tr>
<td>Transverse conduit</td>
<td>Anastomosed to the proximal transverse colon</td>
<td>Distal transverse is anastomosed to the skin</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Continent Diversions</th>
<th>Ureteral Anastomosis</th>
<th>Cutaneous Anastomosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kock pouch</td>
<td>Anastomosed to the proximal afferent nipple made from ileum</td>
<td>Distal efferent nipple of one ileum is anastomosed to the skin</td>
</tr>
<tr>
<td>Miami pouch</td>
<td>Anastomosed (nontunneled) to a proximal segment of tubularized ascending and transverse colon that is folded onto itself</td>
<td>Terminal tapered ileum with three circumferential sutures abutting the ileocecal valve</td>
</tr>
<tr>
<td>Indiana pouch</td>
<td>Anastomosed to the proximal end of the ascending colon (transverse colon not used) in a nonrefluxing seromuscular flap</td>
<td>Terminal nontapered ileum with an ileocecal valve bolstered by Lembert sutures</td>
</tr>
<tr>
<td>Florida pouch</td>
<td>Similar to the Miami pouch</td>
<td>Terminal tapered ileum with two circumferential sutures abutting the ileocecal valve</td>
</tr>
<tr>
<td>Rome pouch</td>
<td>Anastomosed to the ascending and transverse colon but not tubularized</td>
<td>Terminal tapered ileum with two circumferential sutures or appendix</td>
</tr>
<tr>
<td>Orthotopic bladder</td>
<td>Anastomosed to a detubularized ileum suture to remaining detrusor and serosa</td>
<td>Native urethra intact</td>
</tr>
</tbody>
</table>

of continent urinary diversion restores a more physiologic voiding pattern by allowing the patient to void through the urethra instead of a stoma but requires the patient to provide an adequate Valsalva or suprapubic pressure. The orthotopic neobladder is not frequently described in gynecologic oncology because of the tumor pathophysiology and the frequent involvement of the lower urinary tract in gynecologic cancers. Patients who are elderly or have multiple comorbidities or previous radiation damage should undergo a diversion that has a short operative time and requires less intestinal anastomosis, such as the descending or proximal sigmoid conduit that is outside of the radiation field. If extensive radiation damage is evident, the surgeon should evaluate the previous radiation doses and fields before finalizing any type of urinary diversion.

The patient’s desire, self-image, and ability to manage the care of a continent urinary diversion are central to the decision regarding urinary reconstruction. Patients who are young and have few physical limitations can experience the advantages of continent cutaneous diversions—that is, the elimination of external appliances and the ability to maintain socially acceptable methods of continence (Fig. 21.2). Patients who undergo continent cutaneous diversions must be self-motivated and committed to lifelong intermittent self-catheterization. Patients will also need adequate manual dexterity to perform clean intermittent catheterization through the stoma; therefore, elderly patients who lack the desire or manual dexterity to self-catheterize the neobladder will be better served with an incontinent urinary diversion.

Severe medical comorbidities can result in absolute contraindications for both continent and incontinent cutaneous diversions or orthotopic neobladder. Renal function is important because the patient must be able to tolerate postoperative complications such as ureteral stricture or obstruction or recurrent UTIs and pyelonephritis. Patients with bilateral hydronephrosis should have decompression and improvement of renal function before surgery with either ureteral stenting or percutaneous nephrostomy tubes. If impairment of renal function (defined by a creatinine clearance <50 mL/min or serum creatinine >2.0 mg/dL) persists, than one should consider performing just a cutaneous ureteral diversion. Because most urinary diversions involve the reabsorption and recirculation of urinary constituents and metabolites by the specific bowel segment used, normal liver function is optimal to maintain adequate metabolism and elimination of such byproducts.3

Preoperative Management

Preoperative evaluation of every patient undergoing pelvic exenteration and urinary diversion is paramount in decreasing unrealistic expectations, anxiety from changes in body image, unforeseen surprises, and postoperative infectious morbidity and mortality. The morbidity and mortality associated with pelvic exenterations and urinary diversions have decreased over the past few decades as a result of advancements in preoperative care, surgical technique, postoperative care, and interventional radiology techniques. Advancements in surgical technique and surgical critical care have translated into an improved postoperative mortality, which was once reported to be as high as 25% by Brunschwig in 1948.11 Subsequent articles on pelvic exenterations for gynecologic malignancies have documented improvements in the overall mortality rate to 10% to 12%.12,13 The postoperative mortality in the most recent series is about 5%, with a decreasing trend in the past decade, and with causes more often not directly related to the urinary diversion, such as thromboembolic disease, myocardial infarctions, and sepsis.
The great majority of patients who are to undergo pelvic exenteration with urinary diversion and reconstruction are admitted the day of operation, a practice that has changed over the years. Previously, all patients were admitted up to 10 to 14 days before the procedure for total parenteral nutrition, bowel preparation, and consultation with a stoma nurse for "marking" for the colostomy and/or urostomy. It is now recommended that a preoperative evaluation be completed in the outpatient setting before the operation to help the surgeon and patient optimize the surgical outcome. This preoperative evaluation includes a thorough preoperative tumor restaging, preoperative clearance, review of previous radiation therapy, evaluation of the medical and nutritional status of the patient, psychological counseling, stoma nurse consultation, preoperative gastrointestinal preparation, and antibiotics.

**Tumor Restaging**
Magnetic resonance imaging (MRI) and positron emission tomography–computed tomography (PET-CT) are ideal in evaluating the extent and location of the primary or recurrent tumor or urinary defect. This testing enables the surgeon to counsel the patient on the curative or palliative intent of the operation and assists in determining which portion of the gastrointestinal tract is going to be used in the creation of the neobladder. For example, a patient with tumor invasion involving the apical vagina or bladder that is not affecting the bladder neck or levator ani may be a candidate for orthotopic bladder creation. The radiographic findings of possible metastatic disease, which must be confirmed by histopathologic evaluation, would be an essential element in the preoperative counseling of the oncologic patient with regard to her understanding of aborting such a radical procedure if it will not be curative.

**Medical Optimization**
Pelvic exenteration with concomitant urinary diversions and vaginal and pelvic floor reconstructions are radical and extensive surgical procedures, with long operative times, fluid shifts, and blood loss, that would create a significant physiologic strain on any healthy patient, let alone a woman with unstable comorbidities. For this reason, a detailed medical evaluation with emphasis on the cardiovascular and pulmonary systems is important in order to optimize operative and postoperative care. In addition, routine laboratory testing of hematologic, metabolic, hepatic, and renal function is also required to help predict and manage the metabolic derangements that may result from urinary diversion, such as hypokalemia or hypochloremic metabolic acidosis. Poor nutritional state preoperatively can predict poor wound healing, infection, and delayed recovery postoperatively and should be managed by providing preoperative nutritional supplementation and even postoperative total parenteral nutrition.

**Gastrointestinal Evaluation**
A preoperative colonoscopy should be considered to help exclude metastatic disease and other pathologic changes such as diverticula, ulcers, large polyps, or strictures that could affect the reconstruction of any given segment of intestine.

**Previous Radiotherapy Dosages**
A review of a patient's previous radiation therapy, isodose curves, and total dose administered to the pelvis may be of benefit in avoiding use of heavily pretreated intestinal segments as the donor site for the urinary reservoir. Use of areas of intestine that received an additional boost of radiation above 65 Gy with fraction size above 2 Gy results in a higher incidence of toxicity in the treatment of primary or recurrent cancer and should be avoided. Knowledge of such radiation doses to the pelvis by the surgeon will assist in the preoperative surgical planning with regard to which segment of intestine to use in the reconstruction (e.g., descending colon rather than distal sigmoid).

**Psychological Consultation**
The diagnosis of recurrent or advanced pelvic malignancy is traumatic, and this trauma is compounded by the radical and often disfiguring extirpation of all or part of the pelvic organs. This results in alteration in body image, changes in sexual intimacy, and a dramatic shift in the patient's urinary and bowel...
habits. Psychosocial counseling can help a patient understand, face, and begin to accept the changes that she will be undergoing in the postoperative period. The process of accepting and embracing these bodily changes is paramount in the transition to caring for the new external appliances in the immediate and long-term postoperative care.

**Ostomy Nurse or Wound Care Consultation**

It is important to determine the positioning of a urinary and fecal diversion stoma preoperatively. The placement of the stoma is dependent on the segment of intestine that is to be used. A transverse conduit stoma can be created in the upper quadrant more easily than in the lower quadrant. As a general rule, one should attempt to position the continent diversion stoma in either the right lower quadrant or the umbilicus. The umbilicus provides a more pleasing cosmetic result but does require some preoperative planning, so that the surgeon knows to leave an adequate amount of fascia lateral to the umbilical base to allow for a safe fascial closure, as well as to evaluate the periumbilical caliber for hernias that would also complicate its use. A nurse will educate the patient regarding the types of appliances, method and frequency of application, and possible complications. For continent reservoirs, the patient will be educated regarding the proper care and maintenance of the drainage catheter, frequency of catheterization, and frequency of saline flushes of the neobladder. The last is important because this practice prevents overdistention and perforation of the neobladder by removing the mucus that may obstruct the outflow.

**Mechanical Bowel Preparation**

Mechanical bowel preparation is no longer used universally in elective colon resection because a number of randomized trials have shown that there is no benefit in postoperative reduction of surgical site wound infection. However, a number of large retrospective studies compared mechanical bowel preparation with oral antibiotic therapy and found that it can reduce surgical site infection and overall complication rates, except for *Clostridium difficile* infection, which may be increased. The largest study was performed by the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) targeted colectomy data who reviewed 8442 patients and reported that surgical site wound infection decreased from 12% to 6%, postoperative ileus from 12.3% to 9.2%, and anastomotic leak from 3.5% to 2.1%. In addition, a 2015 meta-analysis of seven randomized trials also showed a reduction in overall surgical site wound infection by half, with no effect on deep infections in patients who received oral antibiotics plus mechanical bowel preparation compared with just mechanical preparation. Specific to urinary diversion, a meta-analysis of two randomized trials failed to show an improvement in rates of obstruction, anastomotic leak, or mortality with mechanical bowel preparation. Based on the best available data, it is the chapter authors’ practice to administer both mechanical bowel and oral antibiotic preparation in patients undergoing exenteration and urinary diversion. The preferred method of bowel preparation includes neomycin sulfate 1000 mg and erythromycin 1000 mg orally at 1:00 PM, 2:00 PM, and 10:00 PM the day before operation and 8:00 AM the day of operation, and start polyethylene glycol 8 oz every 10 minutes until 4 L are ingested starting at 6:00 PM the day before surgery.

**Venous Thromboembolism Prophylaxis**

Patients with recurrent or advanced cervical cancer who are candidates for exenteration and urinary diversion have the highest risk factors for venous thromboembolic disease, especially when evaluated with the available predictive models such as the Caprini score. Two retrospective studies reported incidence rates of venous thromboembolism (VTE) of 6% to 9% among patients with gynecologic malignancy who underwent exenteration and urinary diversion. The patients in both these studies received heparin subcutaneously, although the timing of administration and the duration are not well documented. The chapter authors’ recommendation is that all patients receive venous thromboembolic prophylaxis immediately after operation, including pneumatic compression devices and unfractionated or low-molecular-weight heparin during the early postoperative period once the hemoglobin level is found to be stable, and for 30 days. In certain patients who appear to be at high risk clinically of having a deep venous thrombosis, a preoperative venous Doppler ultrasound examination should be ordered, and if the findings are indicative of a deep venous thrombosis, an intravenous vena caval filter should be placed.

**Preoperative Antibiotics**

Because the risk of surgical site wound infection is approximately 5% to 12% for a clean-contaminated wound, and probably higher among high-risk women with previous irradiation and poor nutritional status, preoperative use of antibiotics is prudent. For patients undergoing urinary diversion, the choice for prophylactic antibiotic therapy is best extrapolated from the studies in the colorectal literature. Accordingly, intravenous antimicrobial prophylaxis with a second-generation cephalosporin such as cefoxitin or cefotetan or cefazolin plus metronidazole is warranted. In β-lactam–allergic patients, the intravenous antibiotics indicated include clindamycin plus gentamicin or ciprofloxacin or aztreonam. The antibiotic prophylaxis should be redosed if the surgical time exceeds two half-lives of the drug or if blood loss is greater than 1500 mL.

**Blood Products**

The average blood loss during an exenterative procedure is about 1000 to 1500 mL, and so preoperative preparation to avoid cardiovascular decompensation is wise. All patients undergoing exenteration with urinary reconstruction should be typed and cross-matched for at least 4 to 6 units of packed red blood cells. Equally important is venous access for urgent fluid or blood product resuscitation with a large-bore intravenous catheter such as a 16- to 18-gauge catheter and also a central venous catheter such as a central or peripherally inserted central catheter (PICC) line, placed before the start of the operation.

**Surgical Techniques for Urinary Diversion**

The choice of urinary diversion is complicated and multifactorial. Currently, the surgeon has many more options at his or her disposal compared with the initial description of ureterosigmoidostomy or wet colostomy by Brunschwig (see Table 21.1). Furthermore, the notion that incontinent conduits are the safer alternative for reconstruction of the urinary bladder in patients with recurrent or advanced gynecologic cancers has been evaluated by a number of authors. These studies have compared various forms of incontinent and continent urinary...
diversions and have found them to be equivalent in terms of postoperative morbidity and mortality. The next section describes the various urinary diversion techniques, with special emphasis on the Miami pouch or ileocolonic continent urinary reservoir.

Incontinent Urinary Conduits

After the 1940s, the ileal conduit, first described by Bricker, became the preferred method of urinary reconstruction in order to decrease the complications of a wet colostomy such as recurrent UTIs and pyelonephritis and thus loss of the renal unit.3 The three techniques currently used in the formation of incontinent diversion are the ileal, transverse, and sigmoid colon conduits. In general, these procedures are faster and easier to perform than continent urinary diversions, ideal for patients who have difficulty self-catheterizing or no desire to do so. There remains debate in the gynecologic literature as to which form of conduit is ideal and has the fewest postoperative complications. Most of the largest case series that have either described or compared these various forms of conduit creation have failed to find any significant advantage with a specific host site.29–34 Tabbaa and colleagues (2014) from the Mayo Clinic evaluated short-term outcome of ileal, transverse, and sigmoid conduit procedures in 129 patients. They reported no statistically significant difference in rates of conduit-related complications overall but did find that sigmoid conduits tended to have an increased rate of intervention and repair.29 The overall significant conduit-related complication rate within 30 days was 15% (ileal, 14.7%; transverse, 0%; sigmoid, 20%) and within 90 days was 22% (ileal, 22%; transverse, 0%; sigmoid, 29%). The most common complications included conduits leaks (ileal, 11%; transverse, 0%; sigmoid, 20%), ureteral anastomotic leak (ileal, 4%; transverse, 0%; sigmoid, 0%), and ureteral stricture (ileal, 3%; transverse, 0%; sigmoid, 0%).29 Similar results were reported in 1986 by the group at MD Anderson; these researchers compared all three types of conduits and found that the sigmoid conduit was associated with the highest incidence of complications and the ileal conduit with the lowest.32

The higher rates of short- and long-term complications with both ileal and sigmoid conduit creation have prompted many gynecologic oncologists to recommend the use of the transverse colon, which would avoid use of the segments of intestine within the irradiated field. In addition, the transverse colon anatomically allows for ease of mobilization because of lack of adhesions, facilitates stomal placement, and allows for higher ureteral anastomosis, especially with shortened ureteral lengths. The three most common techniques for incontinent urinary diversion including ileal, transverse, and sigmoid conduits are described in the following sections.

Ileal Conduit Surgical Technique (see Fig. 21.1)

Surgical Steps

Step 1
A 20- to 25-cm segment of terminal ileum is evaluated for any radiation effects or adhesive disease. This segment should be about 15 cm from the ileocecal valve to allow for ample room for the reanastomosis. If the ileum is found to be compromised, then a segment of jejunum can be used to limit postoperative complications. The length of ileum used is dependent on the length needed from the ureters to the skin.

Step 2
The ureterolysis is performed next to allow a determination of the length of the conduit, but sparingly to allow just enough length for a tension-free anastomosis. The left ureter can be tunneled through the sigmoid or the descending colon mesentery. The ends of the ureters are trimmed to produce healthy ends and then spatulated about 0.5 to 1 cm with Potts scissors, which avoids stricturing of the ureteral anastomosis.

Step 3
The gastrointestinal anastomosis (GIA) 55-mm stapler is used to transsect the proximal and distal end through an avascular mesenteric window adjacent to the intestinal serosa to avoid compromising the mesentery. The small bowel can then be reanastomosed in a side-to-side fashion by using a standard approach. Mobilization of the intestinal mesentery is minimized to allow a tension-free approximation to the skin for the stoma.

Step 4
At the proximal end of the ileal conduit (side opposite to the ostomy end), Metzenbaum scissors are used to create a 5-mm opening on both sides of the ileal wall on the antimesenteric end. The distal end is opened at the staple line to irrigate with betadine and saline until clear to remove all remaining fecal material within the ileal conduit.

Step 5
A 7F or 8F urinary diversion catheter is passed through the ureter over a guidewire into the renal pelvis. The distal end of the stent with the guidewire is then threaded through the opening in the ileal conduit and eventually out the distal or stomal end. Both ureters are sutured by using a 4-0 absorbable or delayed absorbable suture incorporating the full thickness of the wall of the ureter and ileum. A number of reports comparing direct anastomosis to antireflux anastomosis have shown that the stricture rate is highest with the antireflux method without a significant decrease in pyelonephritis, hydronephrosis, or upper stone formation, and so as a result the chapter authors prefer the direct anastomosis or Wallace technique. Reinforcing sutures are placed on the peritoneal surface of the ureter and the ileum to decrease tension on the anastomosis.

Step 6
The distal (stomal) end of the conduit is then brought through a preselected site on the abdomen. An approximately 3-cm circular incision is made on the skin and adipose tissue and taken down to the fascia. The authors prefer to make a cruciate incision on the fascia that is ample enough to avoid fascial stricturing. The stoma is then created with a typical “rosebud” technique by placing interrupted 2-0 or 3-0 absorbable sutures through the skin. A portion of the ileal serosa is brought through about 3 to 4 cm from the stomal edge and then passed through the full thickness of the stomal wall opening. The knots are placed laterally on the skin.

Step 7
The ileal conduit should be sutured to the peritoneum just under the stomal opening to avoid peristomal hernia and torsion of the conduit. An 18F catheter with a balloon is placed into the conduit to maintain patency. This catheter, as well as the ureteral stents, can be secured to the skin with suture.

Step 8
The Foley catheter is infused with saline with blue dye to ensure there are no conduit or anastomotic leaks. Finally, a large 19F or 21F closed bulb suction drainage catheter is placed intraperitoneally in the vicinity of the conduit to allow absorption of any urinary leaks.
Step 9
The Foley catheter can be removed 2 to 4 weeks postoperatively, and the ureteral stents can be removed 6 to 8 weeks postoperatively. The intraperitoneal closed bulb suction drain can be removed 2 weeks later if there are no signs of urinary leakage.

Sigmoid and Transverse Conduit Surgical Technique

Surgical Steps

Step 1
The choice between a transverse or sigmoid conduit will depend on the ischemic damage from radiation to the sigmoid, the degree of scarring and adhesions, and the length of mesentary needed for stomal placement. The creation of either a transverse colon or sigmoid conduit begins with mobilization of the splenic flexure, which is the basis for a tension-free colostomy. The distal sigmoid (or transverse or descending) colon is then divided with a mechanical GIA 75-mm staple, and bowel continuity is reestablished with the usual side-to-side technique. The ends can be reinforced with a delayed absorbable 0 imbricating suture.

Steps 2 Through 9
Step 2 through 9 are the same as for the ileal conduit creation. Of note, the fascia cruricata incision should be ample because of the size of the colon and to prevent narrowing and ischemia to the colonic segment.

Continent Urinary Reservoirs Versus Incontinent Diversions

Continent urinary diversions include both cutaneous reservoirs and reservoirs that are connected directly to the urethra (orthotopic neobladder). In a continent cutaneous diversion, a bowel segment is connected to the skin by a stoma on the abdominal wall or umbilicus. In these urinary diversions, the patient must complete periodic self-catheterization to empty the urine. In contrast to a continent cutaneous diversion, an orthotopic neobladder uses an intestinal segment that is then anastomosed to an intact urethra or portion of the bladder. This method of continent urinary diversion restores a more physiologic voiding pattern by allowing the patient to void through the urethra instead of a stoma.

Surgical techniques for the continent cutaneous urinary diversion have evolved considerably over the past 65 years. The different types of surgical techniques for continent cutaneous diversions are the Miami, Indiana, Kock, Florida, and Rome pouches. Each of these techniques differs in the segment of bowel used to create the urinary reservoir, and they have varying rates of complications.

In 1988 Penalver and colleagues were the first to describe the use of the continent ileocolonic urinary reservoir or Miami pouch in recurrent gynecologic malignancies; this is the most common form of continent urinary diversion performed by gynecologic oncologists. In this technique, a low-pressure detubularized colonic reservoir with a tapered ileum and purse-string suture around the ileocecal valve is used as the continence mechanism. The procedure is simple and effective. It has undergone a number of evolutionary changes in technique and trends toward conservative treatment of complications in hopes of improving the functional outcome and decreasing the postoperative morbidity that is associated with the Kock, Indiana, Manz, and Florida pouches.

The dictum that urinary conduits provide a safer alternative to continent urinary diversions has never been confirmed or investigated in a randomized prospective manner among gynecologic oncology patients. Reports from a number of large retrospective single-institution comparative studies have indicated that the overall mortality, preservation of renal unit, and overall complications appear to be equivalent. The largest study, reported by Urh and colleagues from MD Anderson, included 133 patients undergoing exenteration with urinary reconstruction—a 33% (n = 46) with continent urinary diversion and 65% (n = 87) with incontinent conduits. These researchers found no significant difference in overall postoperative complications at 60 days postoperatively except for stone formation, which was more common in the patients with continent diversions 34% versus 2.3% in the incontinent diversions. Salom and colleagues also found no difference in overall postoperative complications at 30 and 60 days postoperatively, renal dysfunction, or mortality among 126 patients managed with a pelvic exenteration with urinary diversion when they compared incontinent conduits versus Miami pouch in a comparative study presented at the annual Society of Gynecologic Oncology meeting. The Miami pouch group did require more surgical intervention for the correction of a neobladder leak compared with the incontinent conduit group, and there was an increased incidence of neobladder stone formation among the Miami pouch patients in whom the pouch was created with automatic titanium staples. Houvenaeghel and colleagues in 2003 compared their series of 124 patients with 14 bilateral ureterostomies, 62 transintestinal incontinent diversions, and 48 continent ileal-colonic diversions and reported an overall complication rate of 37% for complications directly related to the urinary diversion, with continent diversions (6.25%) being associated with a significantly lower rate compared with the other two types (transintestinal diversions, 27%; bilateral ureterostomies, 21.4%). Goldberg and colleagues also reported their experience at Albert Einstein College of Medicine with 103 patients treated with a pelvic exenteration with ileal diversion (n = 65) compared with an Indiana or Miami pouch (n = 38) and found that renal function was preserved in both groups among patients free of disease recurrence. They did not report overall complication rates.

Surgical Technique: Miami Pouch

The Miami pouch is one of the most common forms of continent urinary diversions adopted by gynecologic oncologists in the United States, and therefore the surgical technique is described here. The surgical technique for the Miami pouch was first described by Penalver and colleagues in 1988. In the technique, the ascending and proximal transverse colon are used to achieve a low-pressure urinary reservoir. This technique is especially useful in patients who have undergone radiation therapy because the ascending colon and proximal transverse colon are often unaffected, leading to less risk for postoperative urinary leaks and small bowel complications. The technique has undergone a number of revisions in an attempt to optimize the rate of urinary continence and decrease the ureteral stricture rate and overall morbidity. In a 15-year review of the Miami pouch, which was one of the largest series evaluating long-term outcomes of a single continent urinary diversion method in gynecologic oncology, Salom and colleagues reported a rate of 93% urinary continence and a ureteral stricture rate of 20%, which were treated conservatively in 83% of the patients.
**Surgical Steps**

**Step 1**
In this technique the right colon is mobilized completely along the line of Toldt (Fig. 21.3A). The distal 12 cm of the terminal ileum and the ascending and transverse colon are transected distal to the middle colonic artery with a GIA 75-mm stapler (Fig. 21.3B).

**Step 2**
The isolated intestinal segment, which averages 30 cm in length, is incised at the staple line to irrigate it with betadine and saline until clear, to remove the remaining feculent material and sterilize the reservoir. The incision is extended along the taenia with the Bovie catheter and thus detubularized (Fig. 21.3C). The opened ascending and transverse portions of the colon are anastomosed in a U-shaped fashion along the medial edge to create a low-pressure system (Fig. 21.3D).

**Step 3**
The distal ileum is catheterized with a 14F silicone rubber Foley catheter and tapered over the Foley catheter to this diameter with a GIA 75-mm stapler (Fig. 21.4A). The ilioceleal valve is then reinforced with three rows of 2-0 silk or Ethibond sutures placed 0.5 cm apart (Fig. 21.4B). As a result, the tapered ileum and ilioceleal valve provide a high-pressure outlet to maintain continence.

**Step 4**
Bilateral ureterolysis is performed; the left ureter may have to be tunneled through an avascular window in the sigmoid mesentery near the level of the sacral promontory.

**Step 5**
The ureters are spatulated 5 to 10 mm and anastomosed to the distal ascending or transverse colon—the nonirradiated portion, to avoid stenosis and anastomotic failure (Fig. 21.4C). At this point 7F or 8F double-J urinary diversion stents are inserted in a retrograde manner over a guidewire into the renal pelvis, passed into the newly made ureteral orifice through the posterior wall of the colon, and passed in an antegrade manner through the ileocecal valve and out the tapered ileum or neourethra (which eventually will exit the skin). The stents are sutured to the mucosal wall with 3-0 chromic suture to avoid displacement. The ureters are anastomosed with a 3-0 delayed absorbable suture with a full-thickness interrupted technique, with each stent acting as a guide. The chapter authors no longer anastomose the ureters by using a submucosal tunnel because of the increased probability of stricture formation.

**Step 6**
The anterior wall of the pouch (ascending and transverse colon) is closed with 2-0 delayed absorbable suture (Fig. 21.4D). At this point the neobladder is filled in a retrograde manner, and

---

**FIG. 21.3** Creation of the Miami pouch.
all obvious leaks are reinforced. Both anastomosed ureters are reinforced by placement of three 3-0 delayed absorbable sutures through the serosal surface of both the ureter and colon to minimize tension on the anastomosis.

**Step 7**

Finally, a circular skin incision is made on the right abdomen at the previously chosen area or umbilicus. The excess adipose tissue is excised, and an adequate fascial incision is made to accommodate the ileum or neourethra. Babcock forceps are used to grasp the ileum and bring it out to the skin. Once the fascial opening is found to be ample to avoid neourethral narrowing, the pouch is anchored to the anterior abdominal wall with four to six interrupted 0 permanent sutures to avoid torsion, peristomal hernias, and especially kinking of the pouch-neourethra, which would prevent passage of the Foley catheter during self-catheterization.

**Step 8**

Large drains (at least 19F Jackson-Pratt or Bard Channel drains) are placed in the vicinity of the Miami pouch to allow evacuation of any urinary leak in the pouch or ureteral anastomosis. The authors customarily place an additional drain when a concomitant pelvic exenteration is performed, such as a 16F Malecot drain, because postoperative serous and sanguineous fluid accumulation is excessive.

**Step 9**

The Foley catheter is left in the pouch for 14 days and flushed with 100 to 200 mL of saline solution every 4 hours or until mucus is cleared. The nephroureteral stents are removed on days 14 through 21 along with the Foley catheter after a contrast study of the urinary reservoir and the ureters has been performed to ensure the absence of any urinary leakage, reflux, or upper tract obstruction.

**Minimally Invasive Approach to Urinary Diversion**

Robotic or laparoscopic urinary diversion has been described for some time in the urology literature, from laparoscopic hand-assisted formation of an ileal conduit to complete laparoscopic urinary diversion. Pomel and Castaigne (2004) described the first case of laparoscopic anterior pelvic exenteration with laparoscopic-assisted formation of a Miami pouch in a patient with adenocarcinoma of the cervix with bladder involvement. The authors described use of a 4-cm medial mini-laparotomy adjacent to the umbilicus through which the entire right colon and both ureters are exteriorized to make the ileal and transverse colon anastomosis of the Miami pouch, as performed in an open procedure. The estimated blood loss was 200 mL.
which is much less than the amount reported during an open procedure. The total time of procedure including exenteration and reconstruction was 6 hours, and the patient was ambulatory on the next postoperative day; she experienced no postoperative complications.

Lim (2009) was the first to describe the use of the da Vinci robotic system (da Vinci Surgical System; Intuitive Surgical, Sunnyvale, California) for total pelvic exenteration and formation of an ileal loop urinary diversion. He described the advantages of using the da Vinci system as the ability to dissect down and into the narrow pelvic floor, greater visualization with the binocular optics generating three-dimensional stereoscopic vision, the ability to use the harmonic scalpel to control pelvic side wall vessels and to transect the ligamentous attachments circumferentially around the extirpated structures, finer sewing of the ureteroileostomy because of the articulating wrist of the robotic instrument, shorter operating time, and less blood loss for the patient. The total time for the total pelvic exenteration was 225 minutes, and for the formation of the ileal loop urinary diversion, 120 minutes, with an estimated blood loss of 375 mL.

Martinez and colleagues (2011) were among the first to report a retrospective cohort study comparing outcomes of patients who had undergone laparoscopic pelvic exenteration (14) for gynecologic malignancy and outcomes in those who had undergone an open pelvic exenteration (29) at one institution between 2000 and 2008. All patients had received prior radiation. None of the laparoscopic procedures was converted to laparotomy. Martinez and colleagues reported no difference in operating time, length of stay, postoperative complications, or mortality, but transfusion rate was significantly greater among the laparotomy group. As surgical experience increases with minimally invasive surgery (MIS) procedures, increasing numbers of MIS pelvic exenteration and reconstruction procedures will be performed.

**Orthotopic Bladder**

The formation of an orthotopic neobladder by connecting the intestinal tissue used for the urinary reservoir to the urethra is a technique that has been used in patients after bladder removal for bladder cancer. This procedure has historically been used less frequently in gynecologic oncology patients after exenteration because of tissue damage to the pelvis from radiation, which increases the risk for urethra-neobladder Anastomosis leak and urinary fistula formation, and because of the high risk of recurrence of gynecologic malignancy in the trigone or urethra, thus limiting candidacy for urethra-sparing surgery. In patients who are candidates for this procedure, however, the opportunity to achieve continence and avoid an external appliance for urinary drainage may help the patient achieve better quality of life after operation. To determine candidacy, patients are thoroughly examined and undergo imaging with PET-CT and pelvic MRI, and the urethra and underlying vagina are determined to be devoid of visible tumor.

Formation of a Y-neobladder was described in 1984 by Lilien and Camey. The Camey procedure was modified by Fontana and colleagues in 2004. Chiva and colleagues (2009) published the outcomes of six patients who underwent ileal orthotopic neobladder reconstruction after pelvic exenteration between 2005 and 2008 (Fig. 21.5). All six patients had previously received pelvic radiation. There were no intraoperative complications. Three patients had a postoperative neobladder anastomotic leak, with one requiring reoperation. Patients were satisfied with continence achieved with the neobladder, and all were satisfied with their decision to undergo the procedure.

**Postoperative Care and Management of Postoperative Complications**

**Immediate Postoperative Care**

As important as the intraoperative surgical technique and knowledge, the immediate postoperative care is crucial in minimizing postoperative morbidity and mortality associated with pelvic exenterations and urinary reconstruction. Patients undergoing surgical procedures as radical as pelvic exenteration and vaginal and urinary reconstruction are at high risk of postoperative complications as a result of the radicality of the procedure and the patient comorbidities. The average risk of diversion-related complications has been reported to be approximately 30% to 50% in the largest series. The most common early and late complications include UTI, pyelonephritis, neobladder leak, ureteral leak, difficulty with self-catheterization, ureteral stricturing, incontinence, urinary stones, and fistula formation. This section describes the immediate perioperative care and the evaluation and management of postoperative complications.

**Intensive Care Unit Admission**

All exenterative and urinary diversion patients are admitted to the intensive care unit for close monitoring of vital signs, respiratory fluid, and cardiac status. Many of these patients remain intubated and require blood products as a result of fluid shift, mean blood loss of 1500 to 2000 mL, and other comorbidities. The median intraoperative transfusion amount was 4 units of packed red blood cells (75% of patients) in one study.
another prospective trial performed at the University of Miami, in 77 patients (91% previously irradiated) the average blood loss was 2048 mL (range, 350–12,000 mL), with the average blood transfusion consisting of 7 units of packed red blood cells. 37–39

**Foley Catheter**
The Foley catheter is left in place for 14 days and flushed with 100 to 200 mL of saline solution until clear of mucoid material every 6 hours for the first couple of weeks to prevent accumulation of mucus produced by the colonic mucosa, which can lead to obstruction, neobladder distention and pain, or even perforation. During discharge planning, the patient should be taught how to self-catheterize and flush the neobladder two or three times per day so that she can begin doing so after she has been cleared to do so in the clinic.

**Drains**
The Jackson-Pratt or Bard Channel drains are continued for 10 to 14 days to allow evacuation of all intraabdominal blood and fluid, especially extravasated urine, which can lead to peritoneal irritation. The drains may have to be continued for longer if a significant leak develops.

**Electrolytes**
The choice of intestinal segment such as an ileocolonic neobladder can result in specific metabolic abnormalities such as hyperchloremic metabolic acidosis from the physiologic excretion of bicarbonate through intestinal losses from the colonic mucosa. Of patients who undergo a urinary diversion, 30% to 50% will develop hyperchloremic metabolic acidosis. Most of the reported metabolic abnormalities are clinically asymptomatic and may not pose a problem except in patients who have underlying renal compromise. The chapter authors recommend a basic metabolic panel performed daily for the first few days and then weekly until the results are stable. Electrolyte supplementation such as with potassium and bicarbonate is common in the immediate postoperative period. Another metabolic derangement in urinary diversions is vitamin B₁₂ deficiency. Vitamin B₁₂ is absorbed in the terminal ileum; therefore any urinary reservoir procedure that uses the terminal ileum as the reservoir will result in vitamin B₁₂ deficiency because absorption may be compromised as a consequence of radiation fibrosis. It is often asymptomatic, and it is recommended that vitamin B₁₂ levels be followed in the long-term postoperative period.

**Postoperative Antibiotics**
Antibiotics are used often after pelvic exenteration and urinary diversion in an attempt to decrease the rate of postoperative infectious morbidity. Although a common practice, there is no study proving the efficacy of such practice, and so antibiotic use should be limited to the first postoperative day to avoid the selection of a resistant organism or *C. difficile*.

**Venous Thromboembolism**
These patients are among those at highest of risk for development of VTE, given the presence of recurrent advanced cancer, radical pelvic surgical procedures with vascular endothelial damage, long surgical times of 4 to 8 hours, extensive blood loss, prolonged intubation, excessive fluid shifts, and medical comorbid conditions. All patients should be administered prophylaxis as specified earlier in the section on VTE prophylaxis.

**Nephroureteral Stents**
The nephroureteral stents are removed on days 14 through 21, along with the Foley catheter after a contrast study of the urinary reservoir and the ureters has been performed to ensure the absence of any urinary leakage, reflux, or lower tract obstruction. At this time, the patient needs to be taught proper irrigation and self-catheterization techniques. In the beginning, the patient will perform self-catheterization every 2 to 4 hours and irrigate four times a day to avoid obstruction until all mucus is cleared. The patient may gradually decrease the frequency of catheterization as continence is achieved but should be aware of signs indicating the need for bladder emptying such as abdominal pain and fullness. Follow-up renal sonograms for hydronephrosis are paramount for recognizing and avoiding loss of the renal unit from ureteral strictures, which can occur months to years later.

**Management of Postoperative Complications**
The currently available comparative retrospective studies have dispelled the myth that incontinent urinary diversions are safer for patients, albeit technically easier to perform, and may in fact cause greater morbidity as a result of the chosen intestinal segment within an irradiated field. In one of the largest reviews of incontinent diversion that has addressed this topic, Tabbaa and colleagues (2014) reviewed 166 patients who had undergone incontinent urinary diversion creation, comparing only significant diversion-related complications in the 30– and 90–postoperative day periods, defined as the following: ureteral stricture, conduit leak, conduit obstruction, conduit ischemia, ureteral anastomosis leak, stent obstruction requiring intervention via interventional radiology procedure or reoperation, and renal failure. 29 The overall prevalence of urinary diversion–related surgical complications was 15.1% at 30 days and 20.5% at 90 days. No significant differences were found among patients who had undergone ileal, sigmoid, or transverse colonic conduit formation; however, sigmoid colonic diversions, within the isodose curves, more frequently resulted in conduit-related complications necessitating intervention and additional procedures. Transverse colon conduits were associated with fewer complications, but a low outcome number made statistical analysis difficult. 29 The large cohort studies have reported that the overall complication rate among patients undergoing either incontinent or continent urinary diversion is 40% to 59%, with no significant difference between them. 25,29,39,42,50–52 Houvenaeghel and colleagues (2004) in a study of 124 patients found that the major postoperative surgical complication rate in patients who underwent continent diversion was significantly lower than in those who underwent incontinent diversion and ureterostomy (6.25% vs. 27.4% and 21.4%, respectively; *P* = .004). 42 They also found that surgical complication rates were significantly higher in irradiated patients who underwent incontinent diversion than in irradiated patients who underwent continent diversion (20.5% vs. 4.8%, respectively; *P* = .031). Significant predictive features of postsurgical complications included type of exenteration, anterior versus total (*P* < .014), history of previous radiation (*P* = .002), and type of urinary diversion (bilateral ureterostomy vs. continent and transcolonic diversion; *P* = .001). Karsenty and colleagues reported similar rates of both ureterorenal dilation.
(24% vs. 21%) and overall reoperation (17% vs. 13%) for ileal conduits compared with the Miami pouch group. Many studies have compared the occurrences of specific perioperative complications of incontinent versus continent urinary diversion; these are outlined in Table 21.2.

### Urinary Tract Infection or Pyelonephritis (13% to 42%) (see Table 21.2)

The most common of all postoperative complications are UTIs and pyelonephritis, with an incidence ranging from 10% to 59% and higher in the late postoperative period, often defined as beyond 60 days. Angiolì and colleagues (1998) found that pyelonephritis not related to ureteral stricture or obstruction was found in 13 of 77 (16.9%) patients. All the cases resolved with antibiotic treatment. A review of the first 90 Miami pouch procedures by Salom and colleagues reported that the risk of both UTI and pyelonephritis was 40%; the most common organism isolated was a fungal organism, Candida albicans. In evaluation and management of mechanical dysfunction in continent colonic urinary reservoirs, Ordorica and colleagues noted UTIs in 38% of patients after continent urinary diversions. They suggested that patients with recurrent UTIs that are not related to ureteral obstruction or reflux should undergo fluoroscopy evaluation of the pouch and external limb to detect abnormalities in detubularization and location of areas in urine pooling. Patients with recurrent UTI or pyelonephritis should be evaluated for ureteral obstruction or tumor recurrence with a renal sonogram or computed tomography (CT) urogram, with subsequent management of any anatomic abnormality. If no obstruction is diagnosed, one can consider long-term suppressive therapy with daily antibiotic if more than four episodes per year are diagnosed.

### Difficulty With Catheterization (Continent Diversions) (12% to 54%) (see Table 21.2)

A unique complication encountered among patients undergoing continent urinary diversion is difficulty with self-catheterization. The most common causes for such morbidity are acute angling of the neourethra at the level of the ileocecal valve followed by stone formation and, to a lesser extent, exterior skin structure. In the largest series of continent urinary diversions, involving the Miami pouch, Salom and colleagues reported that only 3 of 90 patients developed stomal skin stricture; this was managed in the outpatient setting. Difficulty with catheterization was defined as the patient’s inability to insert the Foley without evidence of stomal stricture at the level of the skin; it was experienced by 14 out of 90 patients and was diagnosed in the majority (64%) during the first 60 days. Many of the patients who experienced trouble with catheterization in the early postoperative period were found to have deviation of the ileal segment from overdilation of the reservoir, which formed an acute angle from the skin to the reservoir. Fluoroscopic insertion of the Foley catheter was required in 77%. Of the five patients who experienced difficulty self-catheterizing during the late postoperative period, two patients were found to have stones that obstructed the pouch, and one patient was found to have a deviated ileal stomal outlet that required surgical correction. Ramirez and colleagues reported in their series that 25% of patients experienced difficulty with self-catheterization; the majority (80%) were treated conservatively, and only 20% required surgical revision.

In an attempt to prevent such difficulties with catheterization, the ileal segment of the neourethra should be made long enough to allow proper tension-free skin anastomosis, and the base of the pouch should be fixed to the anterior abdominal wall with five or six interrupted sutures placed circumferentially.

### Ureteral (Anastomotic) Stricture (4% to 22%)

One of the most concerning postoperative complications of both incontinent and continent urinary diversions is ureteral anastomotic strictureing, which can lead to hydronephrosis, high-grade obstruction, and eventual loss of the renal unit with renal failure. Patients with ureteral strictures can have flank pain that may or may not be colicky in nature, depending on how insidiously the changes develop and the degree of narrowing. Many of these patients also experience pyelonephritis with back pain, fever, nausea, vomiting, costovertebral angle tenderness, and even sepsis.

In the largest case series evaluating incontinent urinary conduits, Tabbaa and colleagues (2014) reported that the incidence of ureteral stricture among 166 patients was 4%, including one patient with an ileal conduit and no patients with transverse
and sigmoid conduits. In the largest series of continent ileo-cecal urinary reservoirs, Salom and colleagues (2005) reported that during the early (10 of 90) and late (8 of 90) postoperative periods, a total of 20% of patients (18 of 90) developed ureteral stricturing. All patients were treated conservatively with percutaneous nephrostomy, with subsequent internalization of a nephroureteral stent. If an obstruction persisted, then a transluminal ureteral balloon dilation was performed with a balloon angioplasty catheter, which successfully corrected all early ureteral obstructions. Only 25% of patients required surgical ureterocolonic reimplantation. Ramirez and colleagues reported an overall ureteral stricture rate of 8%, with 30% of patients requiring surgical intervention for correction. In the largest retrospective case series comparing incontinent and continent urinary diversions, the researchers found no significant difference in the rate of ureteral obstruction with either technique; rates of stricturing ranged from 8% to 21%. The majority of patients with ureteral stricture can be treated conservatively without surgical correction or reimplantation. In the Einstein series, Goldberg and colleagues reported the highest rate of conservative treatment: 100% for the conduit and Miami pouch groups. Salom and colleagues reported a stricture rate of 20% in both groups, with 83% of the Miami pouch group and 100% of the conduit group treated conservatively. Karsenty and colleagues also found a ureteral stenosis rate of 20% for both continent and incontinent diversions; 100% of the Miami pouch patients and 75% of the conduit patients were treated conservatively (see Table 21.2).

Because ureteral obstruction can be a serious postoperative complication after pelvic exenteration, with potential loss of renal function, the chapter authors advocate periodic evaluation of renal function with a basic metabolic panel and bilateral renal sonogram every 4 to 6 months. If mild hydrenephrosis is diagnosed, a triple renal scan can be ordered to assess flow and function. Only a moderate to severe decrease in flow requires intervention, which includes percutaneous nephrostomy with internalization of a nephroureteral stent. Subsequently, if significant ureteral narrowing persists, balloon dilation can be performed. The last resort for patients who have undergone radiation therapy and multiple operations is reexploration and reimplantation. In the chapter authors’ series of patients with the Miami pouch, and in reports by numerous other authors, the risk of ureterocolonic structuring is decreased if the ureter is anastomosed in an end-to-side fashion, abandoning mucosal tunneling into the colonic pouch. A management algorithm is presented in Fig. 21.6.

Incontinence (7% to 13.3%)

The decision to undergo a continent urinary diversion procedure is one made by a patient in an attempt to avoid the use of any external appliance, to preserve her body image, and to avoid disruptions to her active lifestyle. Failure to achieve urinary continence may result in dependence on a urostomy bag—a situation that often interferes with these goals.

In the earliest reports of the functional outcome of the Miami pouch, Penalver and colleagues (1993) reported a continence rate of 87% after their initial 66 cases. The continence rate improved over the years; in the largest Miami pouch series, reported in 2005 by Salom and colleagues, the continence rate was 92% among 90 patients who underwent a Miami pouch procedure. The rates of urinary continence in other institutions in which the Miami pouch was used as the technique of choice for urinary diversion are comparable, at 80% to 90%. Wilson and colleagues, in their series of urinary diversions with the Indiana pouch, found that the rate of continence was directly related to previous radiation therapy. If patients had undergone previous radiation therapy, the rate of incontinence among patients with the Indiana pouch was 15% compared with 0% among those without prior radiation.

For the 8% to 20% of patients who develop urinary incontinence, the gynecologic oncology surgeon must obtain a specific history regarding the details of the urinary leakage and consider having the patient complete a urolog. If the urinary loss is intermittent and occurs after a prolonged interval between self-catheterization, especially in the morning after a long night of sleep, the patient is asked to perform self-catheterization every 4 to 6 hours or more frequently, depending on the information in the urolog. If the urinary loss occurs in the morning, the patient is educated with regard to decreasing the amount of oral fluid intake 2 to 3 hours before bedtime. If urinary leakage continues after such modifications or if the patient experiences continuous loss, then the chapter authors recommend a urogram to evaluate...
the neobladder and neourethra for decreased capacity from radiation-induced fibrosis or a large space-occupying urinary stone or mucus accumulation. If mucus accumulation is found, neobladder flushes are restarted until all mucus has been cleared; a mucolytic such as acetylcysteine is administered (5–10 mL of a 20% solution mixed in 50 mL of saline is instilled for 20 minutes and then flushed aggressively with 100 mL of saline until mucus is clear, although studies have failed to consistently demonstrate the efficacy of acetylcysteine in decreasing mucus accumulation). Stones can be encountered and can be treated with lithotripsy; if large enough, they may require surgical removal, but this is rare, occurring approximately 2% of the time. Neourethral abnormality such as a pseudodiverticulum or fibrotic contracture of the colonic pouch may necessitate neourethral reconstruction, and the colon may require augmentation. The alternative for a patient who does not desire surgery is a placement of a urethrostomy bag to collect the urinary leak. A novel technique that may be helpful in a patient with urinary incontinence with a normal urogram, normal urodynamics, and an adequate capacity of 400 to 600 mL but whose ileal segment is perceived to be wider than normal is a para-neourethral transcystoscopic collagen injection, performed submucosally at the ileocolonic junction.

**Urinary Stone Formation (7% to 18%)**

Urinary stone formation involving the neobladder or neourethra can result in significant morbidity for patients. Stones involving the urinary reservoir can lead to obstruction of the ureterocolonic anastomosis, with hydronephrosis, decreased bladder compliance with incontinence, difficulty with self-catheterization, and UTIs. Stone formation is almost exclusively a late complication that occurs after postsurgical day 60 and has been reported exclusively in continent diversion. Uhr and colleagues from MD Anderson Cancer Center reported in 2013 that 18% (7 of 40) of patients developed urinary stones in continent diversion created with stapling devices; presenting signs and symptoms included abdominal pressure with distention of the urinary pouch, hematuria, UTIs, and difficulty with catheterization. Of note, stone formation was the only significantly increased complication when compared with incontinent conduits. In this series, all continent diversions were also made with staple devices, and thus the type of diversion may not have been the reason for the increased incidence. What could be factors are the larger size of the reservoir needed to create the low-pressure environment, which requires more staples, and the fact that colonic reservoirs excrete more calcium, phosphate, magnesium, and mucus. Goldberg and colleagues (2006) reported stone formation exclusively in patients with continence reservoirs, in 8%, Similarly, in their case series of 90 Miami pouches, researchers at the University of Miami reported the incidence of stone formation involving the pouch to be 5% to 7%; stone formation occurred most often when a stapling technique was used to construct the pouch. In an attempt to decrease the morbidity of stone formation within the urinary reservoir, we recommend a hand-sewn method rather than the use of the automatic stapling technique. When comparing continent versus incontinent urinary diversion, stone formation is most often associated with the continent methods, as reported by Salom and colleagues (2006) and Goldberg and colleagues (2006). Uhr and colleagues were the only authors to report stone formation in the conduit group (2.3% [2 of 87]).

Management of urinary diversion stone formation can be performed conservatively in the majority of cases (70%–100%). In patients who report vague abdominal or pouch pressure or discomfort, recurrent UTIs, or difficulty with catheterization, a renal sonogram should be obtained to evaluate for the presence and size of a stone in all areas of interest, including the renal calyx, ureter, or reservoir. Special instruction needs to be conveyed to the radiology department and the ultrasound technician regarding the patient’s unique surgical history and anatomic features. In the general population, most nephrolithiasis can be managed expectantly if smaller than 5 mm; less than 20% of patients require other interventions. Conversely, stones larger than 10 mm will require surgical intervention. It must be recognized that the anatomic alterations in the gynecologic oncology patient who has undergone a urinary diversion may necessitate modification of the previously stated guideline because the newly created ureterocolic anastomosis is less pliable and therefore may not accommodate even a 5-mm stone, and frequent evaluation should be performed. If a stone persists or causes moderate or severe hydronephrosis, then the best option is lithotripsy with temporary nephroureteral stent placement. Stones that are 6 to 10 mm in size can be managed more aggressively with cystoscopic- or urethroscopic-directed laser lithotripsy and temporary nephroureteral stent placement. In patients with stones within the reservoir that are multiple and large (2–5 cm), up to 29% require surgical exploration with cystotomy to remove all stones and reestablish neobladder capacity.

**Neobladder-Related Anastomotic Leaks and Cutaneous Fistulas**

Ureteral and neobladder leaks are postoperative complications that are most often seen in the early postoperative period, within the first 60 days. The preferred technique for urinary reconstruction in gynecologic oncology remains the incontinent conduit because of a perceived notion that it is associated with less morbidity. The largest series of incontinent conduits shows that leak rates range from 11% to 19%, which is comparable to reports of case series of continent diversion, with leak rates of approximately 15%,. In fact, comparative studies have shown that there is no statistically significant difference between the methods. The risk factor that has become apparent is the presence of previous irradiation for the advanced primary cancer.

Clinical suspicion that a neobladder-cutaneous fistula is present can be confirmed with retrograde instillation of blue dye into the reservoir. If blue dye is not seen extravasating from the skin, increasing the suspicion for a ureterocutaneous fistula, then an intravenous pyelogram or CT urogram (intravenous contrast only) should be obtained. A CT urogram is the preferred method because it will also help evaluate for a cancer recurrence as the cause of the fistula. Once a neobladder cutaneous fistula has been confirmed to be present, it can be managed with continuous Foley catheter drainage, especially if small. If simple continuous neobladder drainage fails after 4 to 6 weeks or if a large neobladder-cutaneous fistula is diagnosed, then, in addition to continuous Foley catheter drainage, the patient should undergo percutaneous nephrostomies bilaterally without internalization of nephroureteral stents to divert all urine flow. Ample time should be given—up to 4 to 6 months—to allow the fistulous tract to heal before surgical correction is considered.

The most appropriate treatment for a urinary leak of the ureter or enteric complex is conservative management because reoperation in these patients is associated with increased mortality. The principal management strategy is to attempt to divert all urine, thereby optimizing the healing process. A patient who is suspected to have a urinary leak should undergo an intravenous
pyelogram or a CT urogram (without oral contrast) to help localize the area that is compromised. If a leak is localized to the defect within the reservoir, than bilateral percutaneous nephrostomies are inserted, and continuous neobladder drainage is initiated. Of note, ureteral stents are avoided so that urine is not diverted into the pouch. If a ureterocolonic anastomotic (ureter anastomosed to pouch) leak is diagnosed, then a percutaneous nephrostomy is inserted with bilateral nephroureteral stents and continuous neobladder drainage. An abdominal drainage catheter is placed, if one is not present, to drain urinomas and prevent urine from accumulating in the abdomen. After 4 to 6 weeks with no drainage, imaging is repeated; if findings are negative for any leaks, the catheters are removed. If a leak persists or a major leak is encountered, then surgical intervention is mandated. Fig. 21.7 outlines an algorithm for the management of urinary extravasation.

**Gastrointestinal and Pouch-Related Fistulas (2% to 15%)**

Of all the postoperative complications involving pelvic exenterations with urinary diversion, fistulas, especially involving the gastrointestinal and vascular systems, are the most concerning and are associated with the greatest morbidity. The two most important risk factors for fistula formation, especially involving the gastrointestinal tract, include previous radiotherapy and posterior exenteration with low colorectal anastomosis. Salom and colleagues, in 2005, evaluated 126 patients who underwent an incontinent conduit versus a Miami pouch procedure. These authors reported that neobladder fistula formation during the late postoperative period was experienced more often in the conduit group at 14% (3 of 22) than in the Miami pouch group at 8%, but the difference did not reach statistical significance \( P = .189 \). The total fistula rate involving both the gastrointestinal and neobladder sites was 22%.

Houvenaeghel and colleagues in 2004 evaluated both types of urinary diversions in 124 patients and found a greater rate of neobladder fistula formation among patients with incontinent conduits than among those with a Miami pouch (10% vs. 2%, respectively). Urh and colleagues in 2013 completed a comparative study of 133 patients with an overall (gastrointestinal or urinary) fistula rate of 20%, which was similar for both continent and incontinent forms of urinary diversion but did not mention how many were neobladder specific. Goldberg and colleagues, in a review of a series from the Albert Einstein College of Medicine, reported the lowest rate of fistula formation among the other researchers of 7% but did not specify which of the types of urinary diversions were affected most often.

Postoperative neobladder-cutaneous fistulas should be managed conservatively when possible, to avoid the high rate of operative mortality associated with the exenterative patient. Many of the largest case-control series comparing the two forms of urinary diversions have reported a high success rate with conservative management. Salom and colleagues (2004) reported success with conservative management in 67% (6 of 9) of the Miami pouch fistula and 100% of the incontinent conduit group. Berek and colleagues reviewed 75 exenterative patients, of whom 92% had a concomitant urinary diversion; 100% of neobladder-specific fistulas healed with conservative management, and the patients who were found to have a recurrence-associated neobladder fistula all required prolonged nephrostomy for palliation. Hartenbach and colleagues (1995) reported that 2 of 25 patients who underwent continent diversion developed reservoir fistulas (one reservoir-peritoneal fistula and one reservoir-neovaginal fistula with a small leak). Both resolved spontaneously after 22 days and the other healed after 6 months with conservative management and no need for surgical intervention. Neobladder-enteric fistulas involving any segment of the gastrointestinal tract have a low rate of resolution with conservative treatment and often require surgical intervention. Salom (2005) from the University of Miami reported a 3% (3 of 90) rate of entero-pouch fistulas at 3, 5, and 14 months postoperatively in patients who underwent continent diversion with a Miami pouch. All three patients had previously been irradiated; two experienced failure of conservative management with bilateral percutaneous nephrostomies, prolonged total parenteral nutrition, or a combination of both and ultimately required reoperation. In an earlier series of Miami pouch procedures at the University of Miami, Mirhashemi reported specifically on gastrointestinal complications of the Miami pouch; the total rate of fistula development was 26%, but in only 5 of 77 patients (6.5%) was the fistula related to the Miami pouch: three colo–Miami pouch and two enterocutaneous fistulas. In all patients initial conservative treatment failed, and reoperation was
required, with high rates of morbidity and mortality. Karsenty and colleagues (2005) reported on one patient who underwent continent diversion with a Miami pouch in whom a late enteropouch fistula developed between the efferent limb of the pouch and the ileum at 92 months after operation, which was diagnosed after sudden difficulty to self-catheterize. She was treated with repair of the Miami pouch, small bowel resection, and reanastomosis and died 4 months after reoperation from recurrent small bowel fistula and short bowel malnutrition.

If a neobladder-enteric fistula is clinically suspected, CT with oral contrast agent first, followed by intravenous contrast, should be done to evaluate for the presence, location, and extent of the fistula. Although the success rate of conservative management for fistulas is 20% to 30%, the gynecologic oncology surgeon should avoid surgical intervention in these patients because of the significant morbidity and mortality that has been documented in these complicated situations. The chapter authors recommend initiation of long-term total parenteral nutrition, continuous neobladder drainage, percutaneous nephrostomy (without internal ureteral stents), and somatostatin to decrease gastrointestinal fluid production. This management scheme is associated with a high rate of infectious morbidity such as venous catheter infection, sepsis, abscess formation, electrolyte abnormalities, and suboptimal nutrition and protein loss, and so meticulous clinical observation is paramount. Fig. 21.8 outlines an algorithm for the management of urinary pouch–related fistulas.

### Quality of Life

Multiple large case series have compared incontinent and continent forms of urinary diversion and found that both appear to be safe and effective, but most studies lack long-term follow-up or patient satisfaction data. The gynecologic oncology literature has no validated studies comparing improvement in quality of life or body image when an external appliance is avoided. Goldberg and colleagues were the first to report on this issue in their series and found that 54% of patients who underwent continent diversion would have “undoubtedly” chosen an incontinent conduit if given the option again, owing to issues with self-catheterization. In 2007, the World Health Organization (WHO) convened a consensus conference to review all published articles addressing quality-of-life issues related to urinary diversion. They found there was no evidence to support an advantage of one type of reconstruction over the others with regard to quality of life. The urology literature shows that there is no convincing evidence that continent urinary diversion is superior in terms of quality of life compared with any other type of urinary diversion.

### Key Points

- The choice of urinary diversion in gynecologic oncology must take into account a patient’s desire, activity level, manual dexterity, medical comorbidities, and oncologic characteristics.
- The most common continent form of urinary diversion in gynecologic oncology is the Miami pouch.
- Orthotopic techniques (augmenting a patient’s urethral sphincter complex with a segment of intestine) is a viable choice in selected gynecologic oncology patients in whom the distal vagina and urethra are free of tumor.
- Multiple large single-institution retrospective studies have demonstrated that incontinent conduits and continent urinary reservoirs have similar immediate and long-term
complication rates, dispelling the notion that incontinent conduits are safer.

- The average risk of diversion-related postoperative complications for both incontinent and continent techniques is approximately 30% to 50% in the largest series.
- The most common early and late complications include UTI, pyelonephritis, neobladder leak, ureteral leak, difficulty with self-catheterization, ureteral stricture, incontinence, urinary stones, and fistula formation.
- Previous radiotherapy, especially involving a specific segment of intestine used in the urinary diversion, confers the greatest risk of postoperative complication.
- UTI and pyelonephritis are the most common medical complications diagnosed in patients with urinary diversion (25%–40%).
- The most common postoperative diversion-related complication is ureteral strictureing, which can be managed conservatively in 75% to 100% of patients.
- Gastrointestinal fistulas (2%–20%) are encountered much less frequently, but in most (70%–100%), conservative management fails and surgical intervention is required, with high perioperative morbidity and mortality rates.

References


Gynecologic malignancies remain a leading cause of cancer death in women. There are approximately 98,000 new cases and 30,000 deaths annually from gynecologic cancers (including cancers of the ovaries, fallopian tubes, uterus, cervix, vagina, and vulva) in the United States. The treatment of gynecologic cancers has become multimodal and increasingly complex. Gynecologic malignancy rarely invades major blood vessels, but vascular complications occur not infrequently in patients receiving treatment for gynecologic cancer. Surgical dissection in the confines of the female pelvis can be challenging, particularly in the presence of large bulky tumor. Injuries to the major blood vessels in the pelvis are fortunately rare but can be life-threatening. A thorough review of preoperative imaging can help in planning appropriate vascular resection and reconstruction during gynecologic oncology surgical procedures and circumventing major vessel injury. Moreover, late vascular complications can develop after successful pelvic irradiation in the treatment of gynecologic cancers. Newer endovascular interventions are now available and can be effective in the management of vascular complications, including treatment of arterial pseudoaneurysm, iliofemoral venous thrombosis, and arterial occlusive disease. This chapter reviews the contemporary management of common vascular complications encountered in women undergoing treatment for gynecologic malignancies. It describes the surgical techniques for vascular reconstruction during gynecologic oncology surgery and provides an overview of the current endovascular interventions.

**Vascular Anatomy in Gynecologic Oncology Surgery**

The gynecologic oncology surgeon has developed an in-depth knowledge of the vascular anatomy in the female pelvis through training and experience. She or he routinely identifies the major vascular structures when exploring the pelvis and abdomen. In the pelvis, arteries and veins course side by side and are conventionally given the same name (Fig. 22.1). The right and left ovarian arteries typically arise from the lower abdominal aorta, above the origin of the inferior mesenteric artery (IMA), which is often used as a landmark during paraaortic nodal dissection. The lower abdominal aorta ends as it bifurcates into the right and left common iliac arteries. In turn, the respective common iliac artery branches into the external iliac artery laterally, and the internal iliac artery (also known as the hypogastric artery) medially. The external iliac artery and vein form the lateral pelvic wall border and serve as the principal blood supply and venous drainage of the lower extremity, respectively. The location of the internal iliac vessels is typically ascertained during gynecologic surgery. The uterine artery arises from the anterior division of the internal iliac artery. The uterine and ovarian veins course alongside their respective arteries. The left ovarian vein drains into the left renal vein, and the right renal vein empties directly into the inferior vena cava (IVC). The left renal vein typically crosses the midline anterior to the aorta to join the IVC. The incidence of retroaortic and circumaortic left renal vein is roughly 7% and should be recognized when one is performing nodal dissection in the aorto caval window, to avoid injury. The uterine veins typically drain into their respective internal iliac veins, which then join the respective external iliac veins to form the common iliac veins.

The potential for significant bleeding during pelvic surgical procedures is well recognized. Such bleeding may occur, in part, because of the concentration of the major vessels and the intricate venous plexus. Deliberate ligation (or clipping) and division of crossing venous tributaries in the pelvis help avoid vessel tearing and prevent excessive bleeding. There is a rich collateral network between the right and left internal iliac arteries and veins, respectively. In addition, there is a natural anastomotic network between the superior rectal artery, which is the terminal branch of the IMA, and the middle rectal artery, a branch of the anterior division of the internal iliac artery. Similar anastomotic connections exist between the inferior mesenteric vein, which usually joins the splenorenal system, and middle rectal vein, which drains into the internal iliac vein. Hence ligation of the internal iliac artery or vein, or their respective branches and tributaries, is generally well tolerated without clinical consequences. However, when possible, the authors recommend preservation of flow to at least one internal iliac artery, to avoid the rare but potentially disabling occurrence of pelvic ischemia. IMA flow can usually be interrupted without consequences except in rare instances in which it is thought to be a major blood supply to...
the left colon or in the event that both internal iliac arteries are occluded (or surgically ligated). Intraoperatively, the finding of a large IMA (with poor back-bleeding when divided) can indicate that the vessel is an important blood supply to the bowels. A transected IMA can be reimplanted directly onto the aorta or via an interposition reversed saphenous vein graft.

Major injury to the common iliac, external iliac, common femoral, and superficial femoral arteries requires vessel repair or reconstruction to maintain lower limb perfusion. The profunda femoral artery can usually be sacrificed without causing limb ischemia as long as the superficial femoral artery is preserved. Occasionally, extra-anatomic bypasses can be considered when direct anatomic major arterial reconstruction cannot be achieved. The common femoral and iliac veins are the main venous drainage for the lower extremity, and acute ligation of these vessels will commonly lead to severe ipsilateral leg swelling. Occasionally, ligation of the external iliac vein may not cause severe postoperative limb swelling, if it had been chronically occluded and if venous drainage is maintained via collaterals. The two most consistent tributaries of the external iliac vein are the inferior epigastric and the deep circumflex iliac veins (see Fig. 22.1). These tributaries can serve as collaterals between the leg and the abdominal wall venous plexuses in the presence of central venous obstruction involving the external or common iliac veins. Preservation of the external iliac and common femoral veins is recommended to prevent severe limb swelling. However, these can be ligated when massive hemorrhage is encountered during difficult surgical dissection as a lifesaving measure. Similarly, ligation of the common iliac vein or IVC to stop life-threatening hemorrhage is acceptable.

**Gynecologic Malignancy Involving Major Vessels**

At times, gynecologic cancers can abut, invade, or encase major blood vessels. En bloc segmental resection of the involved large blood vessels with extirpation of the tumor may be indicated for curative intent (Fig. 22.2). Decisions regarding operative...
management must involve the consideration of several key factors related to both the tumor and the specific vessels involved. Relevant factors to consider include the extent of the disease, plans for any adjuvant therapy, and the biological responsiveness of the tumor to other treatment modalities. In addition, one must also consider whether the patient has other known sites of residual disease. In these complex cases, careful preoperative planning and collaboration between the primary gynecologic oncology surgeon and a vascular surgeon are paramount for a successful patient outcome. The decision making should be customized to the individual patient, based on the type and extent of the malignancy being treated and the importance of the vascular structure involved.

Preoperative Vascular Imaging

Thorough tumor staging is essential for optimal oncologic management. Improvement in radiologic imaging has contributed to the advances made in cancer staging and treatment outcome. Currently, multidetector computed tomography (CT) with multiplanar rendering provides unparalleled spatial resolution and diagnostic accuracy. The rapid acquisition time and widespread availability of CT scanning make it a preferred imaging modality for tumor staging inside the chest, abdominal, and pelvic cavities. The use of intravenous (IV) iodinated contrast adds better definition of the tissues and solid organs on CT imaging. Patency of the major arteries and veins can generally be determined on routine body CT imaging (when the testing protocol is designed for imaging of soft tissues and solid organs). However, computed tomography angiography (CTA) with early phase acquisition of images after the bolus administration of IV contrast is necessary for detailed evaluation of arteriosclerotic plaque or intramural disease of the major arteries. Delayed phase image acquisition after IV contrast bolus will demonstrate patency of the major veins or presence of intraluminal thrombus (Fig. 22.3). CTA has replaced selective catheter-based angiography in rendering a diagnosis of vascular complication or disease. Selective catheter-based angiography is now reserved primarily for planned therapeutic endovascular interventions. Contraindications to iodinated contrast infusion include severe renal insufficiency and history of allergy (anaphylactic reaction) to iodinated contrast. Recommended renal protection against contrast-induced nephropathy includes hydration, bicarbonate infusion, and oral N-acetylcysteine for patients with a glomerular filtration rate (GFR) less than 45 mL/h. Steroids and antihistamine medications can be administered before IV contrast infusion in patients with reported allergic reaction to iodine.

Magnetic resonance imaging (MRI) has proven usefulness in evaluation of the female pelvis because of its multiplanar capability and sensitivity in tissue characterization. In particular, MRI plays a major role in determining the local and regional extent of cervical cancer. Magnetic resonance angiography (MRA) is performed with the use of IV gadolinium-based contrast material and can be used as an alternative to CTA to assess the major pelvic and abdominal vessels, particularly in patients with iodinated contrast allergy. An additional advantage of MRI is the avoidance of ionizing radiation. However, the spatial image resolution with MRI is inferior and the examination acquisition time much longer when compared with CT. The presence of implantable cardiac devices (pacemakers and defibrillators) or metallic joints is a contraindication to MRI. Patients with chronic renal disease should not receive IV gadolinium because of the risk of nephrogenic systemic fibrosis. In general, time-of-flight (TOF) acquisition during MRI will show adequate images of the major vessels without IV gadolinium.

Duplex ultrasonography is commonly used to evaluate for deep venous thrombosis (DVT) in the upper and lower extremities. Vascular duplex ultrasonography is noninvasive and does not involve radiation. B-mode vascular ultrasonography provides a two-dimensional image of the vessel wall and lumen. Color flow imaging and pulsed Doppler waveform analysis provide a real-time assessment of blood flow characteristics. The diagnosis of venous thrombosis is made when the visualized vein is not fully compressible, echogenic material is present, and color flow is reduced or absent (Fig. 22.4). In addition, venous duplex ultrasonography may be used preoperatively to map out potential venous conduits (such as the great saphenous, femoral, or internal jugular veins) and obtain information regarding location, quality, diameter, length, and depth. Similarly, arterial duplex ultrasonography can provide invaluable assessment of the arterial patency and the presence and location of arterial disease in the lower extremities. Vascular duplex ultrasonography is a practical imaging modality that can be performed in the outpatient clinic or at the bedside. In addition, duplex surveillance is useful in detecting early restenosis and can improve the long-term outcome of vascular interventions (Fig. 22.5).
Complications during gynecologic procedures performed with laparoscopic, robotic, or open surgical techniques are uncommon. However, injury to the major blood vessels in the abdomen and pelvis can be life-threatening. Fortunately, the incidence of inadvertent major intraabdominal vessel injury is less than 1 per 1000 cases. The risk of vascular injury is increased in patients with pelvic malignancy, in part because the bulky tumor mass can distort the surrounding anatomy, making surgical dissection more difficult. In addition, neoadjuvant treatments—in particular, radiation therapy—can lead to the effacement of the tissue planes around the vessels. The

**Acute Major Intraoperative Vascular Injuries**

**FIG. 22.4 Venous Duplex Ultrasound.** The diagnosis of acute deep venous thrombosis (DVT) of a left common femoral vein (CFV) is shown on venous duplex ultrasound images. (A) The thrombus can be seen expanding the noncompressible common femoral vein (V) on transverse view; also shown is the normal noncompressibility of the artery (A). (B) Absent color flow in the CFV on longitudinal view. The same vein had been patent and compressible 1 week before this (C).

**FIG. 22.5 Arterial Duplex Ultrasound.** Arterial duplex ultrasound imaging shows a patent common femoral artery (CFA) to popliteal artery bypass graft (saphenous vein graft [VG]) at the (A) proximal anastomosis (white asterisk) and at the (B) distal part of the vein graft.
following section describes operative maneuvers to prevent or control major bleeding that are available to the gynecologic oncology surgeon.

**Prevention of Vascular Injuries**

Vascular injuries can occur as entrance accidents during the placement of trocars in a laparoscopic or robotic procedure. Injury can also occur during the dissection of perivascular nodal tissue or the dissection of a tumor lying against a major vessel during a laparoscopic, robotic, or open procedure. The optimal method for dealing with vascular injuries is to be aware that these can occur at any time and to never assume immunity against them. Best outcomes are usually the result of meticulous assessment of the anatomy and body habitus of the patient and, in oncologic procedures, the study of the anatomy of the tumor and its relation to the surrounding structures. Trocar injuries occur more frequently in patients with high body mass index (BMI). In oncologic procedures, the larger the burden of the tumor or nodal disease, the higher the risk of inadvertent vascular injuries. Gynecologic oncology surgeons must be able to read the imaging studies of the patient and use them as a road map, rather than relying solely on the radiologist’s report. If proximity to major vessels is detected, particularly in patients who have received preoperative radiation therapy to the operative field, it is wise to recruit the assistance of a vascular or cardiothoracic surgeon who is familiar with the dissection, repair, or replacement of major blood vessels. High-risk procedures that may require a vascular intervention should ideally be done early in the day, when the elements of both expertise and good clinical acumen are at their best.

Large pelvic tumors causing urinary flow occlusion (e.g., hydroureter or hydronephrosis) must also be suspected of having close contact with the other pelvic wall structures. Prior vascular embolization can reduce the bleeding from the tumor itself but does not preclude the possibility of vascular injury. Hypothetically, if a tumor shows evidence of very close proximity to a large artery where tissue planes have become effaced on imaging, placement of an endovascular stent within the involved vessel before oncologic resection may prevent significant bleeding in the event of an inadvertent tear in the vessel (Fig. 22.6). However, the preemptive deployment of an endovascular stent before removal of tumor remains anecdotal, and more studies are needed to justify this technique.

**Principles of Vascular Repair**

A major vascular injury is an emergency, and the best action to control the bleeding is immediate direct pressure on the bleeding point and a call for assistance without hesitation. In minimally invasive surgery this means an immediate conversion to an open procedure, unless the injury is a small tear amenable to laparoscopic or robotic repair. Perseverance in trying to control the bleeding or to repair the defect without appropriate help can lead to excessive blood loss. A small vessel defect can often be repaired primarily with direct finger pressure on the hole to control the bleeding. The basic repair techniques of large defects in a major vein or artery are similar and include three steps: proximal control, distal control, and repair of the site of injury. Temporary control of the hemorrhage can be achieved by direct compression of the blood vessel at the injured site between fingers (best between the index and third fingers). More definitive control of the bleeding is achieved with application of noncrushing vascular clamps proximal and distal to the site of injury. Bleeding from a laceration in a large vessel such as the vena cava or aorta can sometimes be controlled by applying a Satinsky clamp directly underneath (across) the laceration. The Satinsky clamp is typically used for partial occlusion of the aorta or vena cava (Fig. 22.7).

In general, small sharp lacerations or avulsion injuries can be repaired primarily. Crush and electrocautery injuries may require debridement of devitalized tissues to healthy tissues. At times, this requires conversion of a side wall defect into two divided ends (stumps). Reapproximation of unhealthy tissues can lead to the subsequent breakdown of the repair and formation of pseudoaneurysm or vessel rupture. Fine monofilament...
polypropylene sutures are typically used for vascular anastomosis as described later. The authors often use pledgets mounted onto polypropylene sutures to reinforce the repair when the vessel wall surrounding the defect appears friable (Fig. 22.8). When one is suturing vessels, it is important to avoid narrowing of the lumen, which can be caused by catching the posterior wall or taking bites that are too large. Narrowing of up to 50% of the lumen can be acceptable, but anything more necessitates a patch augmentation angioplasty or an interposition bypass replacement. Detailed descriptions of patch angioplasty and interposition bypass are provided later. Anticoagulation is recommended for any complex repair. Intravascular thrombus formation occurs more frequently in the setting of acute vascular emergency because of more traumatic dissection.

The large veins have much thinner walls than their corresponding arteries, and major venous injuries can be much more difficult to repair than arterial lacerations. It is noteworthy to mention the anatomic areas at risk for venous injury during the dissection of large tumors. One of the danger zones for major venous injury is encountered during dissection of the aortocaval window at the aortic bifurcation and ilio caval confluence. Typically, the left common iliac vein crosses behind the aortic bifurcation and right common iliac artery to join the right common iliac vein, forming the lower end of the IVC (Fig. 22.9). Repair of the right or left common iliac vein at the ilio caval confluence often requires mobilization of the overlying right common iliac artery. Occasionally, temporary division of the right common iliac artery may be necessary to gain adequate exposure of the ilio caval confluence behind it. The lumbar veins are also at risk of injury during retroperitoneal dissection. These veins are short but can have a very large caliber, particularly if the IVC is obstructed by external tumor compression, intracaval tumor thrombus, or intrinsic venous disease. Injury to the lumbar veins often occurs during the dissection of retroperitoneal nodes or an attempt to encircle the vena cava. Blood loss from an avulsed or torn lumbar vein can be dramatic if the surgeon is inexperienced. Bleeding from lumbar veins can typically be directly suture ligated with silk or polypropylene sutures with or without pledgets. Another group of veins to view with caution is the deep venous plexus situated around the obturator canal. These veins are encountered during lymph node dissection in or around the obturator fossa or during the dissection of a large pelvic tumor. Bleeding from these sites is best managed with mass ligatures, keeping in mind the close proximity of the obturator nerve, to avoid injury. As mentioned earlier, if the patient’s condition permits, the authors would repair injury to major veins including the IVC and the common iliac, external iliac, and common femoral veins. However, if faced with exsanguination, obliteration of these veins is permissible as a lifesaving measure. Effective mass ligature of torn veins can be achieved.
Speed and precision are of the essence in the management of vascular injuries. The first steps after a major vascular injury is encountered during oncologic resection is to apply direct pressure on the bleeding site and call for help. Precise communication with the anesthesiologist is also paramount. In fact, the surgeon who anticipates the possibility of bleeding should discuss this with the anesthesiologist, who in turn prepares the patient and the team for this eventuality. This involves inserting large venous lines and ensuring that cross-matched blood is available before the procedure. Occasionally, when massive bleeding has occurred, it may be necessary to temporarily control the bleeding by simple direct and constant pressure on the bleeding site and to delay definitive vessel clamping and repair momentarily until the patient has been resuscitated with adequate blood product transfusion and fluid therapy. Giving in to the temptation to peek under the finger to assess the bleeding results only in more bleeding. Continuous severe bleeding can also occur from the surface of the tumor and if neglected can result in significant volume depletion without a true major vascular injury. The use of a round-type bipolar device such as the Aquamantys cautery unit (Medtronic, Minneapolis, Minnesota) can be very helpful to control the bleeding from the raw flat surfaces.

**Surgical Techniques for Major Vascular Reconstruction**

The primary consideration in any vascular repair or reconstruction is to obtain proximal and distal control of the involved vessel. Dissection along the lateral aspects of the involved vessel (rather than circumferential) will usually suffice for placement of occluding noncrushing vascular clamps. Identification, isolation, and control of the arterial branches and venous tributaries will minimize bleeding. In particular, back-bleeding from lumbar arteries can be brisk when the aorta is opened unless they are temporarily clamped or occluded by an encircling loop. Similarly, lumbar veins should be controlled before the vena cava is opened to prevent brisk bleeding from the tributaries. To avoid inadvertent traction injury to the lumbar arteries and veins, the authors often divide them after tying them doubly with 2-0 or 3-0 silk ligatures. In the pelvis, mobilization of the aortic bifurcation and  iliac confluence should be done carefully and deliberately with a clear knowledge of the close relationship of these vessels. The authors use sharp dissection along the major vessels to avoid tear or stretch injuries to the vessel itself or its branches or tributaries. Deliberate ligation and division of the crossing venous tributaries in the pelvis may prevent inadvertent tears.

**Primary Repair and Patch Angioplasty**

There are no large reported series on the vascular reconstructions performed during gynecologic oncology surgical resection.7–9 This section describes the authors’ techniques in reconstructing major blood vessels during oncologic oncology surgical procedures.

Small defects in a large vessel (such as the aorta or IVC) can be reconstructed primarily. Primary repair of a large vessel in a transverse fashion is preferred to avoid luminal narrowing (Fig. 22.10). However, the vessel wall defect is often too long for transverse closure of the vessel, and a longitudinal repair is necessary. Primary longitudinal repair of a small defect in the aorta or vena cava will result in acceptable vessel narrowing. Mild narrowing of the aorta and vena cava usually does not significantly affect flow owing to their large caliber. Larger defects (roughly 20%–50% of the vessel diameter) will require patch closure to limit narrowing of the lumen. Patch angioplasty is often used, and preoperative planning should include having materials available either by preparing the groins or neck or by ensuring that commercial products in the desired material, size, and shape are readily available in the operating room (Table 22.1). Most defects in the iliac veins or arteries will require patch angioplasty reconstruction to avoid significant vessel stenosis in these relatively smaller vessels, compared

<table>
<thead>
<tr>
<th>Table 22.1 Commonly Used Grafts and Patches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autogenous</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>Great saphenous vein</td>
</tr>
<tr>
<td>Femoral vein</td>
</tr>
<tr>
<td>Internal jugular vein</td>
</tr>
<tr>
<td>Internal iliac artery</td>
</tr>
<tr>
<td>—</td>
</tr>
</tbody>
</table>

*Synthetic grafts are commercially available in standard diameters and lengths. Common diameters used to replace iliac and femoral arteries are shown in the table. Large-diameter grafts (18–24 mm) are available for reconstruction of the inferior vena cava and aorta, and bifurcated configurations are used for aortobiliac or aortobifemoral bypass. PTFE, Polytetrafluoroethylene.*
with the cava and aorta (Fig. 22.11). The authors prefer to use the commercially available bovine pericardial patch (shiny side facing the lumen) for the purpose of patch angioplasty for all vessels. These bovine pericardial patches are available in various widths and lengths. Other commercially available materials include polytetrafluoroethylene (PTFE) and polyester (Dacron) patches. Compared with the synthetic patches, the biological bovine patch is more conformable and easier to sew.

**Arterial Reconstruction**

Large vessel wall defects, roughly more than 50% of the vessel diameter, in the aorta and common iliac, external iliac, and femoral arteries are best reconstructed by using an interposition bypass graft. The authors prefer the use of polyester (knitted Dacron) synthetic graft for the aorta and iliac and common femoral arteries for ease of sewing (Fig. 22.12). The authors preferentially use PTFE graft to replace the smaller superficial femoral artery. In general, PTFE is thought to be less thrombogenic for smaller caliber arteries and more resistant to infection than polyester, in part because PTFE graft is more porous than polyester graft. Synthetic grafts are commercially available in various standard diameters and lengths. The great saphenous vein, typically 3 to 6 mm in diameter, is too small to be used in large-vessel reconstruction but is the graft of choice for the smaller mid to distal superficial femoral artery reconstruction. The long-term outcome of major arterial reconstruction is excellent, with 5-year patency rates of over 80%. Occasionally, there may be redundancy of the external iliac artery, which would allow primary reconstruction in an end-to-end fashion after segmental resection (Fig. 22.13). Ligation of the ipsilateral internal iliac artery and mobilization of the entire external iliac artery along the pelvic wall can help provide length to the latter vessel. At times, the proximal internal iliac artery can also be used as a tube graft to reconstruct the ipsilateral external iliac artery.

**Venous Reconstruction**

Long-term patency of the major venous reconstruction is not well reported in the literature. Major venous reconstruction using autogenous venous conduits may have a better intermediate-term patency outcome than synthetic grafts. Reconstruction of the IVC is typically done with ringed PTFE tube graft, or less commonly, with Dacron graft, because there is no large autogenous venous conduit of comparable size. Similarly, the
Intraoperative photograph demonstrates primary end-to-end anastomosis (thin arrow) of the right external iliac artery (A) after tumor resection. The tumor (not shown) was resected en bloc, including the right common iliac artery bifurcation and external iliac vein; the right internal iliac artery stump is shown ligated (thick arrow). The right external iliac vein was chronically occluded, and the tied distal stump is shown (EV). The genito-femoral nerve (N) can be noted branching lateral to the artery.

Vascular Anastomosis and Anticoagulation

Vascular anastomosis is typically performed by using monofilament nonabsorbable polypropylene sutures. These are commercially available either with a single needle at one end or as the "double-arm" type, which has one needle at each end of the suture. In general, the authors use 4-0 polypropylene sutures for the aorta and the vena cava. Alternatively, the larger 3-0 polypropylene suture is useful to repair defects in the aorta with thickened arteriosclerotic wall, and the smaller 5-0 sutures for the smaller defects in the cava with thin wall. As a rule, the authors would use finer sutures for small defects or small-caliber vessels with thin walls and recommend use of 6-0 polypropylene sutures for suturing PTFE graft, even though it is more difficult to thread the small 6-0 needle though the stiff PTFE material. The 6-0 needle leaves smaller needle holes, limiting the bleeding around the suture material on the PTFE graft. The authors have adopted the use of two running sutures for the vascular anastomosis—particularly for the end-to-end anastomosis. In this technique, the posterior wall is fashioned by using the first double-arm suture, and then a second double-arm suture is placed for the anterior wall (Fig. 22.15). This approach allows better visualization of the open vessel and causes less purse-string effect on the anastomosis. Moreover, this technique allows better approximation of mismatched vessel ends. Before the completion of the vascular anastomosis, the proximal and distal clamps are released temporarily to flush out any potential clots or debris. If there is suspicion of an intravascular clot, the balloon Fogarty catheter is passed through the opening of the anastomosis. Balloon thrombectomy is done by first advancing the catheter with the balloon deflated beyond the suspected level of the clot. Next, the balloon is inflated with saline or water in the amount (0.3–1.5 mL) recommended by the manufacturer to achieve the purported size. The inflated balloon is then slowly and gently pulled back, dragging the clot ahead of it through the opening in the vessel. Typically, a 3F catheter is used for tibial arteries, a 4F catheter for superficial femoral and popliteal arteries, and a 5F catheter for iliac arteries and the aorta. The 6F balloon catheter is available for larger vessels, and 2F for smaller vessels. Balloon thrombectomy can be
done in both antegrade and retrograde fashion to remove clots from distal and proximal to the arteriotomy, respectively.

Systemic anticoagulation during vascular reconstruction is usually indicated when the flow of blood in a major vein or artery is interrupted for a prolonged period of time (>30 minutes). The authors recommend use of a 1-mg/kg IV bolus of unfractionated heparin approximately 2 to 3 minutes before interruption of flow, to reach an activated clotting time between 200 and 300 seconds. Systemic anticoagulation can be omitted in the setting of acquired coagulopathy or concern for significant bleeding. Administration of protamine sulfate intravenously is effective in reversing anticoagulation but may not be necessary, because the clinical half-life of unfractionated heparin is approximately 90 minutes.

**Soft Tissue Coverage for Vessels and Grafts**

The main disadvantage in using a synthetic graft for vascular reconstruction is the concern for infection, particularly in the setting of potential bowel or genitourinary contamination. In general, the graft infection rate is low, but the potential exists throughout the remaining life of the patient. In cases in which there is bowel or genitourinary contamination, such as concomitant operations involving the uterus or cervix, bladder or ureter, and small or large bowels, the authors recommend soft tissue coverage of all major vascular reconstructions including autogenous and synthetic grafts when possible. The omentum, if not involved in the primary gynecologic malignancy, is the preferred tissue for covering vascular graft in the abdomen and pelvis owing to its ease of use (Fig. 22.16). Alternatively, pedicle muscle flaps can be fashioned to cover major blood vessels and vascular grafts in the abdomen, pelvis, or groins (such as the sartorius, rectus femoris, gracilis, vastus lateralis, or rectus abdominis; Fig. 22.17). The authors recommend consultation with the plastic reconstructive surgery service when extensive vessel and soft tissue coverage is required.

**Postoperative Care and Surveillance**

The authors recommend long-term daily aspirin (81 or 325 mg) in all patients after any major vascular repair or reconstruction. Antiplatelet therapy has been shown to reduce the risk of acute postoperative thrombosis and improves long-term patency after major vascular reconstruction. Low-dose systemic anticoagulation has been used in patients with venous bypass graft reconstruction with mixed results. For cancer patients, it is reasonable to advocate the use of low-dose low-molecular-weight heparin (LMWH) for 6 months postoperatively to reduce the risk of venous thrombosis. Postoperative leg swelling is common after a pelvic operation, particularly involving major venous repair. Leg elevation and compression therapy can help reduce lower extremity swelling. Early ambulation is recommended for...
all patients. Close surveillance with duplex ultrasonography in the vascular clinic of patients who have undergone major vascular reconstruction imaging has been shown to improve long-term outcomes.

**Other Major Vascular Complications**

**Venothromboembolic Complications**

Venothromboembolic complications including DVT and pulmonary embolism (PE) can be life-threatening in surgical patients. The risk of developing venous thromboembolism (VTE) for women undergoing a major surgical procedure for gynecologic malignancy is estimated at 3% to 6% and extends for several weeks after the procedure. Current evidence-based guidelines by the American College of Chest Physicians recommend extended postoperative pharmacologic prophylaxis with LMWH (40 mg subcutaneously daily) for 4 weeks. Schmeler and co-authors demonstrated significant reduction in the postoperative incidence of VTE in patients undergoing resection of gynecologic malignancies with LMWH injection for 28 days at the University of Texas MD Anderson Cancer Center. In postoperative oncologic patients who develop postoperative VTE,
the current (updated) recommended treatment is therapeutic anticoagulation with LMWH (1 mg/kg every 12 hours) for at least 3 months.  
Extensive iliofemoral DVT can lead to disabling swelling of the affected leg. The use of percutaneous pharmacomechanical thrombectomy and catheter-directed thrombolysis has been shown to reduce limb swelling faster and potentially mitigate the risk for postthrombotic syndrome in patients with extensive iliofemoral DVT. Unfortunately, thrombolysis is contraindicated within 4 to 6 weeks of major abdominal and pelvic procedures owing to excessive risk of bleeding. On rare occasions, severe leg swelling due to iliofemoral DVT can lead to compartment syndrome, and an emergency fasciotomy is required for limb salvage. Rarely, open surgical venous thrombectomy may be indicated in postoperative patients to relieve the severe swelling in phlegmasia alba dolens or phlegmasia cerulea dolens. For patients who develop VTE and have concomitant postoperative bleeding complications or excessive risk of bleeding, placement of an IVC filter is indicated to prevent PE. However, there is an increased risk of recurrent DVT and caval thrombosis in patients receiving an IVC filter. All efforts should be made to remove retrievable IVC filters within 3 to 6 months. Retrievable IVC filters have been associated with a higher rate of complications when left indwelling for prolonged periods of time as compared with permanent filters.  

**Pseudoaneurysm**

Infrequently, arterial pseudoaneurysm can form at the reconstructed vessel sites postoperatively. Risk factors for the development of pseudoaneurysm include infection, irradiated tissues, and immunosuppression. Clinical presentation of patients with pseudoaneurysm can vary from chronic progressive local swelling and pain to acute hemorrhage. Vascular repair of pseudoaneurysms depends on the presentation, location, and etiology. Endovascular repair of pseudoaneurysms using covered stents has become widely accepted. Covered stents are highly effective in excluding pseudoaneurysms of the aorta and iliac and femoral arteries as long as there are adequate proximal and distal landing zones (Fig. 22.18). Conventional direct open surgical repair of pseudoaneurysms remains the gold standard approach when endovascular treatment fails and may be preferred in the setting of local infection. Tissue debridement and healthy soft tissue coverage are other key factors in the surgical management of infected pseudoaneurysms. Pseudoaneurysm can also develop several months or years after initial treatment. Active bleeding or pseudoaneurysm arising from branches of the internal iliac artery can be occluded by using embolic materials such as absorbable gelatin sponges or pledgets, nonabsorbable coils, vascular plugs, or polymerizing agents.  

**Radiation-Induced Vasculopathy**

Women who have had radiation to the pelvis as part of their treatment for gynecologic malignancy can develop radiation-induced vasculopathy several years later. It is postulated that radiation can cause injury to the vasa vasorum and endothelium and induce accelerated arteriosclerosis leading to formation of occlusive plaque in irradiated vessels. Radiation vasculopathy appears to involve the arteries more frequently than veins. It is conceivable that progressive chronic venoocclusive disease may be associated with compensatory collateral formation, and hence affected patients can remain asymptomatic. The external iliac artery appears to be the most commonly affected pelvic vessel in

---

**FIG. 22.18 Arterial Pseudoaneurysm.** A pseudoaneurysm (arrow) involving the right distal external iliac artery is shown crossing the inguinal ligament inferiorly on (A) sagittal computed tomography view and (B) selective contrast angiography. (C) The pseudoaneurysm was successfully excluded with intravascular placement of a self-expandable covered stent-graft.
women who underwent radiation treatment for cervical and vulvar cancer. There is no large reported experience on the management of radiation-induced iliac arterial occlusive disease. The chapter authors recommend expectant medical therapy with exercise, aspirin, and statin therapy for patients with radiation-induced vasculopathy who have noncritical ischemia. Vascular intervention is reserved for limb salvage in women who have critical limb-threatening ischemia. Endovascular interventions including catheter-directed thrombolysis and iliac artery stenting (Fig. 22.19) have produced satisfactory results but are associated with a high rate of re-intervention. Surgical bypass has resulted in seemingly better long-term graft patency and lower re-intervention rates. In general, the chapter authors create an extra-anatomic crossover bypass graft from the contralateral common femoral artery to ipsilateral common femoral artery, provided that the donor artery is normal, avoiding the risks associated with operating in a previously irradiated field. Aortobifemoral bypass remains an option for patients with limb-threatening ischemia due to severe bilateral aortoiliac occlusive disease not amenable to endovascular intervention. Alternatively, an extra-anatomic axillary-femoral artery bypass has also been used for limb salvage with reasonable outcomes. Table 22.2 summarizes the management of seven consecutive women treated at the University of Texas MD Anderson Cancer Center for radiation-induced iliac artery occlusive disease from 2011 to 2015.

**Summary**

Women undergoing treatment for gynecologic malignancy can experience potentially life- or limb-threatening vascular complications, but these are fortunately rare. This chapter reviews the basic vascular reconstruction techniques and current endovascular interventions. In complex surgical resection of bulky gynecologic tumor in proximity to major blood vessels, particularly in an irradiated field, the authors recommend early consultation with the vascular surgery service for assistance in avoiding vascular complications.

**FIG. 22.19 Endovascular Treatment for Radiation-Induced Vasculopathy.** This 40-year-old woman underwent radical hysterectomy, bilateral pelvic lymphadenectomy, and postoperative chemotheraphy and external radiation therapy (50 Gy) for poorly differentiated squamous cell cancer of the cervix stage IB. Two years later, the patient underwent resection for a recurrence in the right pelvic wall and intraoperative brachytherapy (10 Gy). The patient subsequently developed insidious onset of right leg claudication and ischemic rest pain and numbness, 4 years after her last oncologic treatment. Computed tomography imaging with axial (A) and coronal (B) views show thrombosed right common iliac artery (black arrow) and patent left common iliac artery (white arrow); right ureter is noted (asterisk). Selected contrast angiogram (C) shows total occlusion of the right common and external iliac artery. Endovascular intervention including mechanical thrombectomy, catheter-directed thrombolysis, and intravascular stenting of the right external iliac artery (D) successfully restored normal flow to the right leg.
TABLE 22.2 Vascular Interventions in Women With Prior Pelvic Radiation Therapy for Gynecologic Malignancy

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Age (yr)</th>
<th>Cancer Type</th>
<th>Interval Time (yr)</th>
<th>Side</th>
<th>Presentation</th>
<th>Endovascular Intervention</th>
<th>Surgical Bypass</th>
<th>Total Vascular Interventions</th>
<th>Follow-up (mo)</th>
<th>Limb Salvage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40</td>
<td>Cervix</td>
<td>5</td>
<td>R</td>
<td>Subacute</td>
<td>CDT and iliac stent ×2</td>
<td>—</td>
<td>2</td>
<td>20</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>57</td>
<td>Cervix</td>
<td>8</td>
<td>B</td>
<td>Chronic</td>
<td>—</td>
<td>Aortofemoral-</td>
<td>2</td>
<td>48</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>and fem-fem bypass</td>
<td>fem-fem bypass</td>
<td>3</td>
<td>28</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>52</td>
<td>Cervix</td>
<td>5</td>
<td>L</td>
<td>Subacute</td>
<td>CDT and iliac stent ×2</td>
<td>Fem-fem bypass</td>
<td>2</td>
<td>35</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>40</td>
<td>Cervix</td>
<td>6</td>
<td>R</td>
<td>Subacute</td>
<td>CDT and iliac stent ×2</td>
<td>Fem-fem bypass</td>
<td>3</td>
<td>28</td>
<td>Yes</td>
</tr>
<tr>
<td>5</td>
<td>56</td>
<td>Cervix</td>
<td>3</td>
<td>B</td>
<td>Chronic</td>
<td>Iliac stent ×2</td>
<td>Fem-fem bypass</td>
<td>3</td>
<td>27</td>
<td>Yes</td>
</tr>
<tr>
<td>6</td>
<td>65</td>
<td>Vulva</td>
<td>9</td>
<td>L</td>
<td>Acute</td>
<td>CDT and iliac stent ×2</td>
<td>—</td>
<td>2</td>
<td>26</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>51</td>
<td>Vulva</td>
<td>6</td>
<td>L</td>
<td>Chronic</td>
<td>—</td>
<td>Fem-fem bypass</td>
<td>1</td>
<td>9</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*Seven consecutive women with prior high-dose pelvic radiation therapy for cervical and vulvar cancers underwent vascular interventions for critical lower extremity ischemia because of severe iliac occlusive disease at the University of Texas MD Anderson Cancer Center from 2011 to 2015. The mean age was 51.5 years (range, 40–65 years), and the mean interval time from completion of radiation treatment to presentation with limb ischemia was 6 years (range, 3–9 years). All women were without evidence of cancer at the time of the first vascular intervention. The overall follow-up period after revascularization was 27.5 months (range, 9–48 months). Limb salvage was achieved in all patients at the end of the follow-up period, but one patient (patient 1) died from uresepsis and pelvic abscesses at 18 months. The mean number of vascular interventions was 2.1 per patient. The mean primary patency rate of stents after endovascular procedures was 16.2 months (range, 10–25 months), and length of bypass patency after open procedures was 17.8 months (range, 7–48 months). Four iliac stent cases required re-intervention, with mean primary assisted and secondary patency rates of 5 months and 8.5 months, respectively. Interval time refers to the period from completion of radiation treatment to onset of limb ischemia.

B, Bilateral; CDT, catheter-directed thrombolysis; fem-fem bypass, crossover contralateral to ipsilateral femoral to femoral artery bypass; L, left, R, right.

Acknowledgment

The authors wish to thank Karen C. Broadbent and George T. Pismisis for their great assistance on this chapter.

References


Radiation therapy has been a predominant treatment option for cervical cancer since Marie Curie discovered radium. Radiation therapy is the primary treatment for locally advanced cervical cancer, vulvar carcinoma, and vaginal carcinoma. It is used in the postoperative setting to reduce the incidence of local recurrence in patients with endometrial cancer, vulvar cancer, and cervical cancer who have high risk factors. Different combinations of external beam radiation therapy and brachytherapy are used, depending on the setting in which the radiation therapy is being applied. Cure rates with primary radiation for locally advanced cervical cancer range from 50% to 90% depending on stage and nodal status of the patients.

In a retrospective study of 3489 patients with stage I or II cancer of the cervix who were treated with external beam radiation therapy and brachytherapy, Eifel and colleagues found at 10 years an overall risk of 11.2% for grade 3 or higher complications. There were 3.3% rectal, 4.2% small bowel, and 3.0% bladder complications. The investigators found a correlation between smoking and both bladder and rectal complications. Women who had a body mass index (BMI) below 22 kg/m² had an increased risk of rectal and small bowel complications, and women with a BMI greater than 31 kg/m² had an increased risk of bladder complications. In two randomized studies looking at postoperative radiation therapy in patients with endometrial cancer, patients who received external beam radiation therapy had a higher rate of urinary incontinence, diarrhea, and fecal leakage leading to greater limitation in daily activities than patients who underwent observation or vaginal brachytherapy alone.

This chapter is intended to be a guide for the gynecologic oncologist on the most common complications arising from the use of radiation therapy for the treatment of gynecologic malignancies and how to manage them, including both surgical and nonsurgical options depending on the complication and scenario.

**Radiation Oncology**

Complications from radiation therapy are commonly associated with the dose delivered to the organ from the treatment. Many studies have looked at doses and complications, and there are guidelines for the radiation oncologist regarding what dose is recommended for each organ depending on the type of radiation therapy given (i.e., external beam radiation therapy, brachytherapy, or a combination) and the type of cancer being treated, as well as other factors including history of inflammatory disease, age, and previous surgeries.

Recently, newer techniques have been developed in the field of radiation oncology that may reduce the dose to normal tissues and therefore, it is hoped, decrease both acute and late toxicities of radiation therapy. Intensity-modulated radiotherapy (IMRT) and image-guided radiotherapy (IGRT) allow for dose painting and beam optimization, which permit a more conformal dose around target areas while limiting the dose to normal organs and tissues, especially the bladder, rectum, sigmoid, and small bowel (Fig. 23.1). Early retrospective studies and as well as phase 2 studies have shown a decrease in both acute and chronic gastrointestinal toxicities with the use of IMRT. Early results of a phase 3 study in which postoperative patients with either cervical or endometrial cancer were randomized to receive IMRT or standard pelvic radiation therapy were recently presented. The results showed that patients treated with IMRT had lower acute gastrointestinal and genitourinary toxicities as well as a better quality of life during treatment than patients treated with standard radiation therapy, but longer follow-up is needed to see if IMRT reduces chronic toxicities.

In the field of brachytherapy, there also have been improvements with the advent of image-guided brachytherapy. With image-guided brachytherapy, in which magnetic resonance imaging (MRI) or computed tomography (CT)–based imaging is used during the brachytherapy procedure, the dose is being administered to the cervix and parametrium instead of to points determined on the basis of plain-film radiographs (e.g., point A). Doses to normal tissues such as the rectum and bladder are being accurately calculated instead of, again, administering radiation to points determined with plain-film radiographs. Data from many studies show that use of image-based brachytherapy has increased local control while reducing radiation-related toxicities to the bladder and rectum.

It is hoped that as the field expands, more sophisticated radiation techniques will reduce the incidence of radiation-related toxicities.
Fractures

Radiation therapy can induce bone damage in a number of ways. The most common presentation is pelvic insufficiency fracture (PIF), but fragility fractures of the femoral neck and vertebrae (if within the irradiated field) can be seen; an even less common but well-known complication is avascular necrosis of the femoral head (incidence, 0.5%-1%). Because the most common presentation is PIF, the rest of this section will discuss this topic (Fig. 23.2).

The reported incidence of PIF ranges from 1.7% to 89%. However, the majority of studies show a median incidence range of 10% to 20%, with a median time of occurrence between 6 and 20 months from the completion of radiation therapy. The difference in incidence is due to many reasons, including the method of detection, type of lesion reported (symptomatic or both asymptomatic and symptomatic), population, and dose of radiation therapy. The most common risk factor for increased incidence of PIF after radiation therapy includes older age, postmenopausal status, and low BMI and body weight. Data regarding other risk factors, including decreased bone mineral density before radiation, smoking status, and alcohol intake, are mixed.

There are a number of ways to diagnose PIF; presently, the best imaging study available is MRI or CT (Fig. 23.2). Most patients with PIF develop pelvic pain if the fractures are symptomatic; this usually occurs within the first 2 years after treatment. It is important to perform imaging in these patients to diagnose the cause of the pain, which could include recurrence of the cancer, pathologic fractures, and other conditions, including PIF. The morbidity of PIF can be high, involving pain, time away from work, and definitely a decrease in quality of life. The most

**FIG. 23.1 Comparison Between Intensity-Modulated Radiotherapy (IMRT) and Three-Dimensional Conformal Plans.** (A) shows a four-field plan. The red line represents the 45-Gy line, which is the full prescription line, and it encompasses the entire bladder and the rectum (arrows A and B). The red line (45-Gy line) also is encompassing some of the bowel (arrow C). The red contour represents the postoperative vagina, and the blue contour represents the nodal bed. (B) shows an IMRT plan in the same patient. The 45-Gy line (red) conforms more to the nodes and vagina, and there is less distribution of the 45-Gy dose to the bladder (arrow A) and bowel (arrow B). The sparing of these normal tissues leads to a reduction in acute and long-term toxicities. As in (A), the red contour is the postoperative vagina, and the blue contour represents the nodal bed.

**FIG. 23.2 Pelvic Fracture.** Computed tomography (CT) scan of patient treated with radiation therapy for cervical cancer. The arrow points to a fracture in the left pubic symphysis. Patient had cement injected into the fracture and had complete resolution of symptoms.
common sites of PIF include the sacral ala, sacral body, ilium, acetabulum, pubis, and lumbar spinal vertebrae.\textsuperscript{15}

The most common management for PIF is conservative, including bed rest, gentle mobilization, and analgesia, with resolution of symptoms occurring within 3 to 30 months\textsuperscript{13,16,17} if the fractures are stable. If the fractures are unstable, the patient should be referred to an orthopedic surgeon. For better mobilization, the patient should be referred to a physical therapist. Once a fracture has been diagnosed, it is important to assess the full bone health of the patient, including secondary screens for other bone abnormalities, a bone density test, and vitamin D levels. The vitamin D levels should be treated until greater than 50 nmol/L. Bisphosphonate therapy should be used only if the patient meets the criteria for treatment, which include the confirmed diagnosis of osteoporosis (i.e., a T-score of −2.5 standard deviations or lower), but referral to an endocrinologist is very important because there is currently no evidence that there is any benefit to its use for secondary prevention.\textsuperscript{10,18}

Cementoplasty, particularly sacroplasty, is a treatment option for painful PIFs. Small prospective\textsuperscript{9,20} and retrospective\textsuperscript{11,22} studies have shown improvement in pain with this treatment. The treatment involves percutaneous injection of polymethyl methacrylate (PMMA) into the fractured area. A clinical review of the literature showed that patients treated with sacroplasty have a significant improvement in pain scores\textsuperscript{22}; however, these are early results, and larger prospective trials are needed. Sacroplasty is associated with its own complications including infection, embolization, and movement of the cement.

Prevention is probably the most important treatment for PIFs. This includes a full assessment of the patient's bone health including assessment of fracture risk and a bone density test, as well as measurement of baseline vitamin D level before the start of radiation therapy. It is recommended that all postmenopausal women should be treated empirically with vitamin D to levels greater than 50 nmol/L.\textsuperscript{10} There is little evidence that bisphosphonates should be used as primary prevention of PIFs, but if a patient is at high risk for hip or vertebral fragility fractures and meets the criteria for bisphosphonate therapy on this basis, then national guidelines should be followed.\textsuperscript{16} Future work is needed in the treatment and prevention of PIFs that occur in patients treated with radiation therapy because it can affect the quality of life of patients who survive cancer.

**Necrosis**

The most common site of necrosis is at the apex of the vagina, especially in patients treated definitively with radiation therapy for cervical cancer. This usually occurs within 1 month and up to 16 months after treatment. Symptoms include pain and bleeding. The best treatment for vaginal necrosis is conservative, including topical estrogen cream (about 1 g per applicator) two to three times a week and, if possible, the use of a hydrogen peroxide douche (50/50 3% hydrogen peroxide and water), but it is best to start with estrogen cream even in patients with endometrial cancer for a short period of time. The necrosis usually resolves within a month with conservative treatment.

Total vaginal necrosis is a rare complication that manifests with sudden onset of pain (worsened by sitting) that starts 4 to 16 months after the completion of treatment. Clinically, fibrinous changes and later ulceration of the vagina are seen, followed eventually by consolidation with concentric granulation of the vaginal wall.\textsuperscript{23} In some patients, the necrosis will proceed to fistula formation between the vagina and the bladder or rectum. It is important to rule out disease progression or recurrence with biopsies, but one also needs to be careful about being too aggressive with biopsies, because these could also lead to fistula formation.\textsuperscript{24} Factors contributing to necrosis include total dose of the radiation therapy, fields used in the treatment, medical comorbidities (particularly cardiovascular disease), and smoking.\textsuperscript{25} Treatment options include surgical debridement, sitz baths, hydrogen peroxide douches, local and systemic antibiotics, estrogen replacement, and analgesics.\textsuperscript{23} Hyperbaric oxygen may be also helpful. Hyperbaric oxygen should be used if conservative measures fail, usually after 4 to 6 months of conservative management. Treatment consists of at least 20 sessions but usually between 20 and 30 sessions of 100% oxygen inhalation at 2.4 atmospheric absolutes (ATAs) for 60 to 90 minutes in a hyperbaric chamber.

Cervical and uterine necrosis after radiation therapy is also a rare event but occurs in 1.75% of all women treated, and the incidence is higher in women who are current smokers (2.76%).\textsuperscript{25} Clinical presentation includes vaginal discharge with pelvic or abdominal pain, as well as, in some patients, vaginal bleeding. Mean time for occurrence is 9.3 months (range, 2.2–20.5 months). As with vaginal necrosis, biopsy should be performed to rule out recurrence of disease, but care needs to be taken not to be too aggressive to avoid fistula formation. Treatment should again be conservative initially, including counseling for smoking cessation for all patients, vaginal douching with hydrogen peroxide, consideration of antibiotics (usually metronidazole 500 mg twice a day or three times a day for 10 days) and pain control.\textsuperscript{25} Fig. 23.3 shows a patient who had necrosis after treatment and was treated with conservative management as
described earlier; within 6 months she had complete resolution of the necrosis and was disease free 3 years later.

Sometimes, conservative management does not work, and additional treatment may be needed. There are data suggesting that administration of pentoxifylline (PTX) and vitamin E (tocopherol) works for osteoradionecrosis.\textsuperscript{26,27} The usual treatment includes 400 mg of PTX twice a day and tocopherol 1000 IU once a day.\textsuperscript{27} A literature review showed that this treatment may be beneficial for colorectal anastomosis and postburn scars, in addition to radiation-induced skin and soft tissue injuries.\textsuperscript{26} Fig. 23.4 shows positron emission tomography–computed tomography (PET-CT) images of a patient with stage IIIIB cervical cancer. The images include the initial PET-CT scan, a PET-CT scan taken 3 months after radiation therapy, and a scan taken 6 months after treatment with PTX and tocopherol. She was completely disease free 1 year after completion of treatment.

Necrosis usually resolves with conservative management within 4 to 6 months. Hyperbaric oxygen may also be useful if there is no improvement within 4 months. In patients in whom there is no improvement within 6 months and who continue to be symptomatic, surgical debridement and resection should be considered, but this should performed only in a worst-case scenario because it can lead to further complications such as fistula formation.

**Rectal Proctitis**

Radiation proctitis is radiation-induced rectal mucosal injury including loss of mucosa, endothelial swelling in the arterioles, and subsequent fibrosis of connective tissue and arteriolar end-arteritis\textsuperscript{28} (Fig. 23.5). The incidence rate varies from 2% to 39% and is definitely correlated with the dose the rectum receives during radiation therapy. Data show that the risk of proctitis increases as a function of mean rectal dose, ranging from 2% for patients receiving 50 Gy or less to the rectum to 18% for patients receiving 80 Gy or more to the rectum.\textsuperscript{29} Patients with inflammatory bowel disease\textsuperscript{30} and acquired immunodeficiency syndrome (AIDS)\textsuperscript{29} are at a higher risk of radiation proctitis.

Radiation proctitis has been subdivided into two different phases depending on timing of the symptoms. Acute proctitis occurs during or within 3 months of radiation therapy and is usually transient and self-limiting; patients have diarrhea, urgency, and tenesmus, in general without rectal bleeding.\textsuperscript{29,31} Chronic proctitis either continues from the acute phase or begins after a latent period of at least 90 days, and symptoms include rectal bleeding that can progress to intestinal obstruction from stricture and sepsis.\textsuperscript{31}

There are no consistent guidelines or randomized studies on the treatment of symptomatic proctitis, and most patients are treated empirically with individualized treatment. The

---

**Fig. 23.4 Cervical Necrosis.** (A) Pretreatment positron emission tomography–computed tomography (PET-CT) scan of a patient with stage IIIIB disease with the arrows pointing to the fluorodeoxyglucose (FDG)-avid disease in the cervix and uterus. (B) The 3-month PET-CT scan shows a decrease in the size of the cancer, but FDG-avid disease is still present in the cervix. Arrow A is pointing to the bladder; arrow B is pointing to the normal uterus with no FDG activity; arrow C is pointing to the persistent FDG-avid disease in the cervix. All biopsies were negative for recurrent disease. Patient was placed on pentoxifylline and tocopherol. (C) PET-CT scan 3 months later shows complete resolution of all necrosis without any FDG activity. Arrow A points to the bladder; arrow B shows the normal cervix with a platinum seed placed at time of brachytherapy; arrow C indicates the rectum.
treatment options are either medical or endoscopic therapies. Medical therapies include antiinflammatory agents that have 5-aminosalicylic acid (5-ASA) as an active ingredient, antioxidants, sucralfate (oral or enema), steroid enemas, and hyperbaric oxygen. Of these medical treatments, the best data are from the use of sucralfate and hyperbaric oxygen. One study showed a benefit of oral sucralfate; another study showed a benefit of the use of sucralfate enemas, with 92.3% of the patients reporting improved symptoms with no complications. Another study showed that sucralfate enemas were better at preventing and managing acute rectal toxicity than hydrocortisone enemas, and therefore at the present time there is limited use of steroid enemas in the treatment of acute or chronic proctitis.

Hyperbaric oxygen has shown promising results in a large randomized trial involving 120 patients in which there was a significant improvement in the healing responses with better bowel-specific quality of life in patients with refractory radiation proctitis. Another study showed little clinical difference in outcome between hyperbaric oxygen therapy and argon plasma coagulation (APC) for radiation proctitis, with minimal side effects.

Formalin instillation was initially used in 1986 for the treatment of radiation proctitis and is effective in approximately 48% of patients with chronic proctitis. In general, this approach is safe, but bleeding, perforation, and fistulas have been reported. However, in recent years, endoscopic therapies have become the treatment of choice for patients with chronic radiation proctitis with symptomatic bleeding. The goal of endoscopic therapy is the obliteration of the telangiectasis; the options include contact methods, such as heater probe and bipolar electrocautery, and noncontact methods such as laser therapy, APC, radiofrequency ablation, and cryotherapy. Recently, APC has become the preferred first-line endoscopic therapy for hemorrhagic proctitis. APC uses inert argon gas as a conducting medium, and a bipolar diathermy current is delivered. Limited depths of coagulation (0.5–3 mm) and uniform and predictable application are some of the advantages of APC. With the use of APC in one study there was improvement in rectal symptoms such as tenesmus, improvement in diarrhea in 60% to 75% of patients, and alleviation of rectal bleeding in 80% to 90% of patients. Multiple treatment sessions are recommended, up to a total of five, for diffuse lesions. Complication rates vary from study to study, but the most common complication is rectal or anal pain, which usually resolves spontaneously. Rare complications include urinary retention, necrosis, and arteriovenous fistula; the rate of strictures varies among different studies but ranges from 2% to 13%.

Surgery is the last resort for patients who do not improve with conservative measures, including those with symptoms of refractory bleeding and strictures leading to obstruction. Types of surgical interventions range from simple proximal diversion to

FIG. 23.5 Proctitis. Colonoscopy from a patient treated with radiation therapy for cervical cancer. The images show radiation proctitis with hypervascularization (arrows).
formal resection with or without an anastomosis. Rectal proctitis is a common side effect from radiation therapy; it is hoped that as newer and more sophisticated radiation techniques are developed, the incidence of this complication will be reduced. However, until that time, nonsurgical treatments such as APC are the treatment of choice for patients with chronic proctitis with symptomatic bleeding. Early detection and early treatment will minimize the effect of complications. Surgical options should be reserved for refractory symptoms.

**Urologic Complications**

The most common urologic complications encountered after the use of radiation therapy in the treatment of patients with gynecologic malignancies are cystitis, ureteral stenosis, and fistula formation. Unlike bowel complications, bladder complications have a long latency period before presentation—up to 15 to 20 years after the completion of treatment. This is primarily because of the cumulative and progressive nature of the injury from radiation therapy. Factors contributing to necrosis include total dose of the radiation therapy, fields used in the treatment, medical comorbidities (particularly cardiovascular disease), and smoking.

**Radiation Cystitis**

The incidence of radiation cystitis after radiation therapy differs widely owing to varying definitions, assessment, and patient selection. However, the reported incidence is 5% to 10% for grade 3 or higher toxicity and up to 50% if grade 1 is included. In the acute phase, patients have urinary urgency and bladder pain; in the chronic phase, patients can have recurrent macroscopic hematuria, incontinence, and urgency-frequency syndrome, which could lead to end-stage symptoms including a fibrotic, shrunken low-compliance bladder that requires urinary diversion. Cystoscopy will typically demonstrate white and frosted mucosa with telangiectasia in its early stages (Fig. 23.6).

Preventive measures have been tried with mixed results. Anecdotally, patients have been placed on cranberry juice or pills for symptoms or for prevention of urinary tract infection. A systematic review and meta-analysis of 13 randomized controlled trials showed that cranberry-containing products are associated with a protective effect against urinary tract infections. The mechanism is thought to be secondary to the strong antioxidant properties of these products, which reduce the inflammatory process in the bladder mucosa. Cranberry pills or juice should be considered the first step in the treatment or prevention of cystitis.

The use of chondroitin sulfate has been evaluated in the treatment of interstitial cystitis and painful bladder syndrome. It is believed that chondroitin sulfate replenishes the radiation-induced loss of the glycosaminoglycan (GAG) layer, which is one of the causes of cystitis. Hazewinkel and colleagues published the results of a randomized study including 20 patients—10 patients receiving weekly intravesical instillations of GAG during radiation therapy, and 10 control subjects who did not receive any instillations. These researchers found that patients receiving the instillation reported less bothersome overactive bladder symptoms during treatment. However, the study was small, with limited follow-up, and no data were included on the development of late bladder complications with

![FIG. 23.6 Cystitis.](image1)

Four images from cystoscopy in a patient with cervical cancer treated with radiation who developed blood in her urine. The images show hypervascularity seen with radiation cystitis. These show severe changes. The patient was treated with hyperbaric oxygen, and her symptoms improved.
the use of the instillation. Similarly, there are reports that instil-
lations of sodium hyaluronate during external beam radiation
or brachytherapy can reduce the incidence of acute radiation
cystitis.42–44 Ots and colleagues reported that the instillation of
intravesical hyaluronic acid before each brachytherapy session
significantly reduced the incidence of radiation-induced cystitis
compared with no intravesical hyaluronic instillation in patients
with cervical or endometrial cancer after the second (20.8% vs.
40.4%) and fourth sessions (10.9% vs. 31.9%).44 The instillations
were generally well tolerated and definitely could be a means
of preventing radiation-induced cystitis, but larger studies with
long-term follow-up are needed.

Acute radiation cystitis is usually self-resolving and responsive
to anticholinergic drugs (such as oxybutynin [Ditropan] or soli-
denicin [VESiCare]) and analgesic therapies (such as cran-
berry pills or phenazopyridine [Pyridium]) to alleviate symp-
toms. Rest and hydration are usually recommended.43 Chronic
radiation cystitis is difficult to manage because there are few
treatment modalities and the response rates vary with current
treatments. Before starting any treatment, it is important to rule
out any other causes of symptoms, including urinary calculi,
tumors, infections, bleeding anomalies (medications and coag-
ulopathies), and other non–bladder-related sources of bleeding
(renal or ureter).29 The first line of treatment is hydration, blood
transfusion in case of excessive blood loss, and continuous blad-
der irrigation with saline until the urine is clear via a three-way
catheter to remove all clots.29,42

If symptoms persist, more aggressive measures are used; these
measures focus on sterilization, bladder lavage, and treat-
ment of hematuria.45 The options include instillation of alum
or formalin, fulgurations with electrocautery, hyperbaric oxy-
gen therapy, internal iliac embolization, intravesical hydro-
static pressure therapy, and laser coagulation. Each of these
approaches is associated with varying degrees of success and
bladder toxicity. Irrigation with agents such as alum or forma-
lin causes chemical corrosion of the bladder urothelium and
coagulates the bladder tissue to stop bleeding. Alum has most
commonly been used, and based on clinical trials, the response
rate ranges from 50% to 100%.45; however, toxicity has been
reported, especially in pediatric patients and in patients with
renal failure.46

Hyperbaric oxygen reverses the pathophysiology of radiation
cystitis by inducing neovascularization, enhancing angiogen-
esis and granulation tissue formation, and optimizing immune
functions at the cellular level.29 Studies have shown success
rates for symptom control of 27% to 92%.45 In one systematic
review of hyperbaric oxygen therapy for the treatment of cysti-
itis, no clinical difference in outcome was seen between the use
of hyperbaric oxygen and hyaluronic acid.46 Hyperbaric oxygen
therapy is expensive and time-consuming, with each individual
treatment session lasting about 60 minutes.

Laser coagulation is new in the field of cystitis and has been
shown to be effective in small studies. The use of laser coagula-
tion with the neodymium:yttrium–aluminum–garnet (Nd:YAG)
laser has been shown to be effective but can cause damage to the
bladder tissue, leading to fibrosis, scar formation, and bladder
perforation.29 More recently, the potassium titanyl phosphate
(KTP) laser has been used and has shown some efficacy with less
toxicity than the Nd:YAG laser. Talab and colleagues observed
that the procedure was able to stop bleeding 92% of the time and
that the average hematuria-free interval after ablation was 11.8
months (range, 1–37 months).47

As a last resort before surgery, formalin instillation may be
used. However, it is very toxic, and dilution is needed to reduce
the toxicity. In patients in whom medical treatment has failed,
surgical approaches include cystoscopy with fulguration of
bleeding points, embolization or ligation of arteries, and urinary
diversion with or without cystectomy.42 Success has been seen
with the aforementioned surgical interventions, but these pro-
cedures are also associated with high morbidity and mortality.48

Radiation cystitis is a painful condition that can affect the
quality of life of patients who develop it; unfortunately, current
treatments only target the symptoms, are associated with high
toxicity, can be expensive, and have varied success rates. Stud-
ies are ongoing to find novel therapies that can treat and cure
this condition, including instillation of tacrolimus.45 However,
early detection is very important in controlling symptoms and
performing treatment.

Ureteral Stenosis

The reported incidence of radiogenic unilateral or bilateral dis-
tal ureteral stenosis after radiation therapy for cervical cancer is
0.4% to 2.7%.59 However, in older autopsy series, much higher
incidence rates of radiogenic stenosis of 9% to 19% were reported
and ureteral stenosis was found to be the second most common
cause of death in patients after curative radiotherapy for cervi-
cal cancer.50 The time of occurrence of asymptomatic cases after
treatment with radiation may be several decades, and the condi-
tion may become apparent only when elevations of serum creati-
nine or upper tract dilation are detected incidentally. The cause
of stenosis may be obstruction, but more commonly the ureters
have lost their motility and therefore propulsive function, result-
ing in unilateral or bilateral obstructive nephropathy and hydro-
nephrosis (Fig. 23.7).50 Hydronephrosis carries a risk of septic
infections and loss of renal function. Tumor progression is the
most common cause and needs to be ruled out, especially if the
stenosis is detected within the first 2 to 3 years after treatment;
however, if the complication occurs 5 or more years after treat-
ment, the most common cause is complication from radiation
therapy. The most common location of stenosis from radiation
is 4 to 6 cm proximal to the ureteric orifice, close to the area
of highest radiation exposure and closest to the parametral tissue.50
Risk factors include total radiation dose, fractionation of radia-
tion application with decreasing complications with higher frac-
tionation, older age, previous surgical intervention, local chronic
inflammatory process,51 hypertension, and diabetes mellitus.52

Treatment of radiogenic urologic hydronephrosis involves
placement of stents or nephrostomy tubes to help increase flow.
However, these measures are usually only a temporary solution
because the devices have a limited lifetime and their presence
affects the quality of life of patients. Secondary and permanent
management is reconstruction including ureterolysis alone,
end-to-end reanastomosis, ureteral reimplantation by uretero-
cystoneostomy, transureteroureterostomy, ureteral substitution
with ileum, or urinary diversion with ileal, jejunal, or transverse
colonic conduit; however, all these procedures have a high rate
of complications, and few patients are good candidates for any
of these procedures.50 The decision to perform or not to per-
form reconstructive surgery or urinary diversion must take into
account many factors including underlying malignancy, the
localization and length of ureteric stenosis, extent of coexisting
other radiogenic complications, and patient factors including
age, comorbidities, and desire to undergo a major procedure
with considerable risk of complications.50
Radiogenic ureteral stenosis is a rare complication, but the incidence increases with time from treatment. Patients may have life-threatening consequences, and the complications may affect the quality of life of patients. The permanent treatment for symptomatic radiogenic ureteral stenosis is reconstruction; however, this procedure has a high rate of complications and is not a viable option for the majority of patients.

**Sexual Function and Quality of Life**

Quality-of-life studies point to vaginal morbidity and associated sexual dysfunction as important causes of long-term distress in survivors of gynecologic malignancies treated with radiation therapy. Late side effects on the vaginal mucosa from radiation therapy are caused by increased collagen production within the fibroconnective tissue, leading to shortening and narrowing of the vagina (stenosis) and atrophic changes of the mucosa. Vaginal stenosis is the most prevalent complication, with an incidence that varies from 1.2% to 88%. Tumor extension in the vagina, brachytherapy dose, and treated length of vagina are considered risk factors for vaginal stenosis. Vaginal dilation is widely advocated by many national guidelines to help prevent or decrease this morbidity to help women recover sexual function after treatment, as well as to allow for an adequate pelvic examination after treatment for signs of recurrent disease. However, patient compliance varies; a report from the United Kingdom states that only 48% of women complied with the guidelines given to them. Some of the reasons given by women for not complying with the guidelines have included an unfavorable experience with the use of the dilator as well as deep psychological and emotional implications linked to the intrusive nature of dilation.

Studies have shown that dilation therapy during radiotherapy has failed to demonstrate any benefit and may be detrimental, and therefore this practice is not recommended. The findings of cases series, correlation analysis, and comparison with historical controls involving dilation therapy after treatment suggest that its use is correlated with less stenosis. Therefore the recommendation with limited data is to use dilators or a sexual equivalent at least two or three times a week starting 2 to 3 weeks after treatment; the duration of use in years is not known, but the minimum is 2 years.

Pelvic pain is another complication of both surgery and radiation therapy for patients with gynecologic cancer. The incidence of pelvic pain has been reported to be as high as 38% in survivors of cervical cancer. Although the pathophysiology of pain is not well understood, internal scarring and adhesions secondary to surgical and radiation therapy may potentially cause pain. Pelvic floor muscles affected by adhesions and inflammation may spasm, shorten, and have trigger points, resulting in pain. Manual physical therapy interventions such as Thiele massage, trigger point therapy, and scar releases are several common types of manual therapy interventions that help with pelvic pain in patients after treatment of cancer. Physical therapists should be consulted when a patient has chronic pelvic pain after treatment.

Other complications that affect quality of life of survivors of gynecologic malignancies are more difficult to treat, including fatigue, chronic bladder and bowel complications, and leg edema. A sexual therapist should see patients with sexual dysfunction, and it may be beneficial for the patient to see the sexual therapist before having issues or early in her care. Larger studies are needed to assess the efficacy of specific interventions targeted at pain, sexual dysfunction, psychological distress, and health-related quality of life in women who have undergone radiation and chemotherapy for gynecologic malignancies.

**Fistulas**

**Vesicovaginal Fistulas**

Vesicovaginal fistulas are rare and are related to extent of disease, previous history of surgery or type of surgery, and a history of smoking (Fig. 23.8). Patients who have had a hysterectomy followed by radiation therapy are at a 5- to 10-times-increased risk of fistula formation. Nonsurgical repairs including bladder drainage with indwelling urinary catheter, injection of fibrin glue, and electrocautery are useful for small fistulas but have a lower success rate in patients with previous radiation therapy and
therefore are not used often in patients with radiation-induced fistulas.\textsuperscript{73} Surgical techniques can be applied transvaginally, transabdominally, transvesically, or in combination.\textsuperscript{74} Transvaginal surgery has a lower risk of complications, lower blood loss, and a faster recovery period but should be reserved for small fistulas and is not the best approach for complex radiation-induced fistulas.\textsuperscript{75}

The transabdominal approach is the best approach for complex, recurrent, or large (>3 cm) fistulas,\textsuperscript{76} as well as for fistulas either high in the supraretrigonal region or near the ureteric ostium.\textsuperscript{77} The transabdominal approach in which interposition grafts are used has a high success rate (>95%).\textsuperscript{78} Grafts may originate from the omentum, gracilis muscle flap, rectus abdominis muscle flap, myocutaneous flap, myofascial flap, or bladder mucosa.\textsuperscript{79} However, in general, the majority of these grafts have not been studied in the setting of patients with previous radiation therapy. Mraz and colleagues described a study in which a seromuscular intestinal interposition graft was used in four patients with a previous history of radiation therapy.\textsuperscript{80} All four patients had no leakage over the next 3.5 to 5 years after operation.\textsuperscript{80} The advantage of using an intestinal flap is that it is a nonirradiated tissue that is well vascularized, but the technique requires highly specialized, interdisciplinary trained experts.\textsuperscript{74} The majority of patients with large, extensive fistulas will need urinary diversions.

**Bowel Fistulas**

The incidence of fistulas between the rectum and the vagina, cervix, or uterus after radiation therapy ranges from 0.3% to 6%.\textsuperscript{81} Contributing factors for the risk of fistula formation include dose of radiation therapy, especially to the rectum, high blood pressure, diabetes, smoking, infections, and postsurgical adhesions.\textsuperscript{82} Radiation may cause tissue ischemia by obliterating endarteritis of the small vessels and tissue fibrosis.\textsuperscript{83} The most common site for fistula formation is the rectum,\textsuperscript{84} especially in patients treated for cervical cancer, and the fistulas are usually classified according to the localization and dimension. They may be classified as anovaginal fistulas or low or high rectal fistulas.\textsuperscript{82} Small fistulas are those up to 2.5 cm in diameter, and large fistulas are those with larger diameters (Fig. 23.9).\textsuperscript{82}

Surgical treatment of a radiation-induced rectovaginal fistula is difficult because of the irradiated tissue surrounding the fistula, and a fecal diversion of a terminal colostomy may be the best treatment in many patients because it improves symptoms and quality of life with a low rate of complications, even though it does not treat the underlying disease. For low small fistulas, authors have reported favorable results with a direct approach to the fistula through the perineum by interposition of muscles between the vagina and the rectum (gracilis, sartorius) or use of bulbocavernous-labial flaps (Martius).\textsuperscript{83–85} All of these procedures are accompanied by a temporary fecal diversion. For high fistulas, most authors suggest rectal resection with coloanal anastomosis. Some small high fistulas may spontaneously heal after a diverting procedure (<20%).\textsuperscript{86} The use of plugs and fibrin glue in radiation-induced fistulas is not recommended, because the short and frequently epithelialized canal of the fistula is not suitable for such interventions;\textsuperscript{87} a prospective two-center study failed to show good results for fistula plugs.

**Conclusion**

A large number of patients with gynecologic malignancies will undergo radiation therapy as part of their treatment. There are both early and late toxicities associated with the use of radiation therapy, especially as more patients are cured or are long-term survivors. These toxicities may be morbid and definitely have an impact on the quality of life of patients. However, these toxicities are becoming rarer because of new and improved technology in radiation therapy including IMRT and image-based brachytherapy. Late complications are difficult to treat, and thus strategies for prevention and early detection are crucial. It is important to ensure that a specialist in radiation-related complications is an integral part of the team managing such complications, in order to ensure faster and more effective approaches in the management of such complications and ultimately to decrease morbidity and improve patients’ quality of life.

**FIG. 23.8 Vesicovaginal Fistula.** (A) and (B) Computed tomography (CT) scan of the pelvis of a patient treated with radiation therapy for cervical cancer. (A) Early image of the fistula between the cervix and bladder (B). Arrow points to the early communication between the bladder and vagina. (B) Image 1 month later. There is a complex fluid collection in the vagina with air pockets in both the vagina and the bladder, representing an infected vesicovaginal fistula (arrows). Patient underwent a urinary diversion with bilateral nephrostomy tubes. R, Rectum.
Complications of Radiation Oncology

FIG. 23.9 Rectal-Sigmoid Fistula. (A) and (B) Patient had been treated with definitive radiation therapy for cervical cancer. She was a smoker. She developed a fistula between the uterus and the rectum and sigmoid as shown in these two images. She did not have recurrent disease. The images show the communication between the uterus and rectum with gas inside the uterus. (A) The arrow points to the communication between the uterus and the bowel. B, Bladder; U, uterus. (B) Another sagittal image of the same patient; white arrow points to the communication between the uterus and bowel. The bright seed (black arrow) is the platinum seed that was placed into the cervix during the patient’s brachytherapy procedure. B, Bladder; R, rectum; S, sigmoid; U, uterus.

References


Laparoscopy is the surgical approach of choice for many gynecologic oncology procedures. Reduced morbidity, shorter hospitalization, and a more rapid recovery have been associated with minimally invasive surgical approaches when compared with laparotomy.\textsuperscript{1,2} Incisional morbidity, including vascular and viscous injury, postoperative hernia, infection, and pain remain important concerns. Use of fewer and smaller incisions during laparoscopy may be expected to further minimize these risks. Laparoendoscopic single-site surgery (LESS), or single-incision laparoscopy, describes the use of one small skin incision to complete laparoscopic surgical procedures. Despite having pioneered the use of single-incision laparoscopy for the performance of tubal sterilization, gynecologic surgeons faced technical limitations that prompted the use of multiple incisions for completion of more complex procedures.\textsuperscript{3} Recent advances in instrumentation have provided the opportunity to revisit the concept of laparoscopic surgery limited to the use of a single incision.\textsuperscript{4}

**Feasibility of Laparoendoscopic Single-Site Surgery in Gynecologic Oncology**

In 2009 an initial report of LESS in gynecologic oncology described 13 women who underwent procedures including endometrial and ovarian cancer staging, pelvic lymph node dissection, risk-reducing hysterectomy and bilateral salpingo-oophorectomy (BSO), and adnexal surgical procedures for removal of complex masses.\textsuperscript{5} After publication of this report, several authors from multiple institutions established the safety and feasibility of performing complicated gynecologic oncology procedures including paraaortic lymphadenectomy and radical hysterectomy with LESS.\textsuperscript{6–15}

Treatment with LESS of 100 women with endometrial cancer was described in a retrospective report.\textsuperscript{10} This report included the initial cases at each of three participating institutions, thus incorporating learning curve experiences. Pelvic and paraaortic lymphadenectomies for staging were completed in 48 and 27 women, respectively. A median of 16 pelvic nodes (range, 1–31 nodes) and 7 paraaortic nodes (range, 2–28 nodes) were retrieved. The median operative time and estimated blood loss were 129 minutes (range, 45–321 minutes) and 70 mL (range, 10–500 mL). Four intraoperative complications were reported. Conversion to laparotomy was necessary in one woman to repair an obturator nerve injured during pelvic lymphadenectomy. Conversion to multiport laparoscopy (MPL) to obtain control of paravaginal bleeding was necessary in one other patient. No other conversions from LESS occurred. Long-term follow-up was not reported.

Treatment of 22 women with early-stage cervical cancer with LESS radical hysterectomy was described in another retrospective, multiinstitutional report.\textsuperscript{15} The approach was successful in 20 women (91%). A median of 22 pelvic lymph nodes (range, 4–34 nodes) were removed. Median operative time and estimated blood loss were 260 minutes (range, 149–380 minutes) and 60 mL (range, 25–350 mL). Truncal obesity necessitated placement of one additional port in one woman. Laparotomy was performed in a second woman for repair of an external iliac vein injury that occurred during lymphadenectomy. Surgical margins were negative for cancer in all women. One woman had two pelvic lymph nodes containing metastatic disease. Another woman had microscopic metastatic disease in the parametria. No recurrences were noted during limited follow-up (median, 11 months; range, 1–35 months).

These reports, although establishing the feasibility of LESS as an approach for gynecologic oncology procedures, are necessarily limited in their ability to demonstrate potential advantages compared with other minimally invasive approaches. Furthermore, the reports come from surgeons with extensive experience in MPL and LESS, potentially limiting the applicability of the results to surgeons more broadly. Regardless, these reports should prompt consideration of the possible benefits of LESS compared with MPL and whether the performance of studies sufficiently designed to compare clinical outcomes between the two approaches is indicated.
TABLE 24.1 Randomized Controlled Trials Comparing Laparoendoscopic Single-Site Surgery (LESS) and Multiport Laparoscopy (MPL)

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Procedure</th>
<th>Number of Patients</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chen</td>
<td>2011</td>
<td>Hysterectomy</td>
<td>100</td>
<td>Single surgeon. Decreased pain scores at 24 and 48 hours postoperatively and lower accumulated doses of pain medication with LESS compared with MPL. Otherwise comparable outcomes.</td>
</tr>
<tr>
<td>Song</td>
<td>2013</td>
<td>Hysterectomy</td>
<td>40</td>
<td>Single surgeon. Higher cosmetic satisfaction with LESS compared with MPL at 1, 4, and 24 weeks after operation.</td>
</tr>
<tr>
<td>Fagotti</td>
<td>2011</td>
<td>Adnexal surgery</td>
<td>60</td>
<td>Single institution. Decreased pain scores at 4 hours postoperatively and lower accumulated doses of pain medication with LESS compared with MPL. Otherwise comparable outcomes.</td>
</tr>
<tr>
<td>Hoyer-Sorensen</td>
<td>2012</td>
<td>Adnexal surgery</td>
<td>40</td>
<td>Single institution. Standardized preoperative pain medication regimen. No difference in overall pain scores or pain medication use between LESS and MPL.</td>
</tr>
</tbody>
</table>

Potential Benefits of Laparoendoscopic Single-Site Surgery

Numerous observational studies have explored the potential benefits of LESS compared with MPL with regard to gynecologic procedures, for both benign and malignant indications. Most of these retrospective studies have focused on adnexal procedures or hysterectomy. Far fewer prospective studies have been completed (Table 24.1). In general, reported outcomes including operative time, estimated blood loss, length of hospital stay, and complication rates appear comparable between approaches. Proposed benefits of LESS compared with MPL include reduction in postoperative pain, reduction in incision-related morbidity, and improved cosmesis. Although these seem plausible and may make intuitive sense, their confirmation requires further study with the performance of additional, larger, randomized controlled trials.

Postoperative Pain

Postoperative pain after gynecologic surgical procedures varies and is affected by both patient and technical factors, both modifiable and unmodifiable. Given that LESS uses only one small skin incision, in theory it should further minimize incision-related pain compared with MPL. The hypothesis that LESS may result in reduced postoperative pain has been explored in several comparison series, as well as in three randomized controlled trials.

In the first randomized study, 100 women underwent laparoscopically assisted vaginal hysterectomy performed with either LESS or MPL. A single team of a lead surgeon and an assistant surgeon performed every procedure. MPL was accomplished with a 12-mm umbilical port and three 5-mm ports (suprapubic and right and left lower abdomen). A single 1.5-cm intramuscular skin incision and a 1.5- to 2-cm fascial incision were used for LESS. Two women in the LESS group required placement of an additional port (suprapubic) to assist with adhesiolysis, but no cases required conversion to laparotomy. No differences in operative time, estimated blood loss, length of stay, or complication rate were noted between the groups. Abdominal and shoulder pain were independently assessed by using a visual analog scale (VAS) at 12, 24, and 48 hours postoperatively. This prolonged evaluation was possible because of the culture of longer hospitalization (length of stay >3 days for both groups) in the country where the study was performed (Taiwan). The VAS consisted of a nongraduated 10-cm line ranging from “no pain” to “pain as bad as it could be.” Pain medication (meperidine and/or tenoxicam) was administered when requested, and accumulated doses were summated at 48 hours after operation. Abdominal pain scores at 24 and 48 hours after operation were significantly lower in women who underwent LESS compared with MPL (3.64 ± 2.75 vs. 5.08 ± 2.76 at 24 hours, P = .011; and 1.94 ± 2.31 vs. 2.84 ± 2.07 at 48 hours, P = .043). Accumulated doses of pain medication were significantly lower in women who underwent LESS compared with MPL (74.4 ± 24.25 vs. 104.8 ± 57.08 mg of meperidine, P = .001; and 16 ± 13.4 vs. 33.6 ± 28.7 mg of tenoxicam, P < .001). Neither postoperative pain 12 hours after operation nor shoulder pain at any time point differed between surgical approaches. Although women were randomized to either LESS or MPL for completion of the procedures, they and the investigators collecting data, including pain scores, were not prevented from identifying the number of incisions present postoperatively. This lack of blinding with respect to surgical approach could conceivably have influenced the results. Details concerning anesthesia and intraoperative administration of pain medication were not reported and may also have affected postoperative pain measures independent of surgical approach.

In the second randomized study, 60 women underwent adnexal surgery with either LESS or MPL. MPL was accomplished with a 10-mm umbilical port and three 5-mm lower abdominal ports. A single 1.5- to 2-cm open umbilical incision was used for LESS. The anesthesia protocol, including administration of pain medications intraoperatively, was strictly standardized. Of note, no preoperative or postoperative local anesthesia was used at skin incisions. No intraoperative complications or conversions to laparotomy occurred in either group, and operative times were similar. Postoperative pain was evaluated at rest and after Valsalva maneuver at 20 minutes and 2, 4, and 8 hours after operation by using a similar VAS.
Investigators collecting these postoperative data were blinded with regard to each patient's surgical approach. Women in the LESS group reported reduced pain at each interval, both at rest and with Valsalva maneuver. The difference was greatest and statistically significant at 4 hours postoperatively ($P = .004$ and $P = .01$ at rest and after Valsalva maneuver, respectively). Women in the LESS group also used less pain medication (8 vs. 21 doses of paracetamol 1000 mg orally or intravenously, $P = .001$). No difference in pain was reported between surgical approaches at the time of discharge (mean hospital stay of 1.3 vs. 1.4 days for LESS and MPL, respectively). Thus, although the measured differences in postoperative pain and analgesia used achieved statistical significance, their clinical significance may be debated.

A third randomized study compared postoperative pain after adnexal surgery for benign disease via LESS versus MPL in 40 women. Of potential significance in this study was a standardized protocol of preoperative analgesia. One hour before operation, all women received 1.5 g of paracetamol, 100 mg of diclofenac, and 10 mg of oxycodone orally. Furthermore, 0.5% bupivacaine hydrochloride was injected subcutaneously immediately before each skin incision. Both overall postoperative pain and shoulder-specific postoperative pain were assessed at 6 and 24 hours after operation by using a 10-point scale. Women in both groups reported similar levels of pain at 6 and 24 hours after operation (2.2 vs. 1.9, $P = .62$ at 6 hours; and 3.0 vs. 2.5, $P = .35$ at 24 hours for LESS vs. MPL, respectively). Furthermore, no difference in postoperative analgesia needs was noted. The impact of the rigorous preoperative analgesia protocol as well as local anesthetic injections on these results is unclear but may have contributed to improved pain measures across surgical approaches. It is curious to note that women who underwent LESS reported significantly more shoulder pain than women in the MPL group (2.4 vs. 0.6, $P = .01$ at 6 hours; and 3.1 vs. 1.4, $P = .03$ at 24 hours, respectively). The authors hypothesized that increased shoulder pain in the LESS group may be explained by the longer operative time of 42 minutes compared with 31 minutes for MPL. Overall, currently available evidence suggests postoperative pain and use of analgesia may be reduced after LESS compared with MPL, but the clinical significance of this difference may be small.

### Incisional Morbidity

Use of only one incision, and creation of that incision by using an open technique, may be theorized to result in less morbidity related to incisions and port placement, such as vascular, gastrointestinal, or nerve injury. These injuries may be highly clinically significant when they occur but are fortunately relatively rare with MPL. Their potential minimization with LESS, although desirable, would be challenging to demonstrate given statistical sample size requirements. As anticipated, no study to date has demonstrated a statistically significant reduction of incisional morbidity with LESS as compared with MPL.

Paradoxically, one concern regarding LESS is that use of a larger umbilical incision may result in more postoperative hernias in this location. Previous studies have demonstrated a correlation between trocar size and risk of incisional hernia, lending validity to this concern. A recent meta-analysis of 19 randomized controlled trials, including 1705 patients, comparing LESS and MPL for completion of either cholecystectomy or appendectomy suggested a slightly higher incidence of incisional hernia after LESS. Trocar-site hernia was noted in 2.2% of patients in the LESS group, compared with 0.7% in the MPL group (odds ratio [OR], 2.26; 95% confidence interval [CI], 1.00–5.08; $P = .05$). Secondary analysis of 14 trials considered to be of “high or acceptable quality” demonstrated an OR of 2.88 (95% CI, 1.09–7.61; $P = .03$). The authors acknowledge a number of limitations of their meta-analysis. Detailed information regarding fascial closure method and follow-up assessment was not reported in several studies. Incisional hernia incidence was a primary outcome in only 2 of the 19 studies. In addition, 1 of the 19 reports contributed a relative weight of 20.1% of the combined data. In this industry-sponsored study in which participating surgeons had limited experience with LESS, rate of trocar site hernia was 10% for LESS and 1.6% for MPL. If the results of this study are excluded in sensitivity analysis, the higher rate of incisional hernia with LESS is not maintained (OR, 1.85; 95% CI, 0.58–5.86; $P = .30$). Regardless, the recommendation for “meticulous closure of the fascia” during LESS is reasonable.

Results from a retrospective cohort analysis of 211 women who underwent LESS for a variety of gynecologic indications at four institutions are reassuring. Surgical closure was performed in either a running fashion or with interrupted figure-of-eight sutures by using a delayed absorbable 0-Vicryl suture (Ethicon, Somerville, New Jersey). After a median follow-up of 16 months, umbilical hernias occurred in 2.4% of patients ($n = 5$), between 3.5 and 18 months postoperatively. Most had additional risk factors, such as obesity or connective tissue disorders. In women lacking these risk factors, the rate of umbilical hernia was only 0.5%. These rates are comparable to those reported for MPL.

### Cosmesis

The cosmetic result of an LESS incision is dependent on the preoperative size and appearance of each particular patient’s abdomen and the surgeon’s ability to “hide” the incision. Although it seems logical that a single incision hidden within the umbilicus would provide cosmetic improvement compared with the use of three to five abdominal incisions in MPL, studies examining this question in gynecologic surgery are scarce.

Satisfaction with cosmesis after LESS or MPL for hysterectomy was the primary outcome of a randomized controlled trial including 40 women. The Body Image Questionnaire (BIQ), a validated tool for assessment of body image and cosmetic satisfaction, was completed before operation and at 1, 4, and 24 weeks after operation. A 12-mm umbilical port and either two or three 5-mm ports in the lower abdomen were used for MPL. Of note, there were no significant differences between the two groups with regard to clinical demographic data, operative times, uterine weights, perioperative complication rate, postoperative hospital stay, postoperative pain scores, or anergic use. Women in the LESS group reported significantly higher cosmetic satisfaction compared with those in the MPL group at 1, 4, and 24 weeks after operation ($P < .01$).

In a survey study, 250 women were shown a series of photos of an unscarred female abdomen. Each photo was marked with typical incision lengths and locations for gynecologic procedures performed using LESS, MPL, or robotic-assisted laparoscopy (RAL). When asked to rank the incisions in order of preference, the first choice was MPL, LESS, or RAL 56.4%, 41.1%, and 2.5% of the time, respectively. Notably, the MPL photo showed a 5-mm incision at the umbilicus compared with
a 25-mm incision for LESS. Whereas the locations of all three additional MPL incisions were drawn below the waistline, this is often not practical in reality.

**Incisional Utility**

Although not captured in published reports, we, as well as many other gynecologic surgeons who are currently performing LESS, find the longer incision at the umbilicus used in LESS to be useful in a number of situations. Most incisions for MPL are meant to minimize fascial disruption. Removal of even normal-size adnexa, as in the case of risk-reducing BSO, let alone a substantial adnexal mass, is generally not possible without significant expansion of one of the incisions or use of a colpotomy. After extension of an incision and mass extraction, performance of additionally indicated procedures may be challenging owing to difficulty with maintenance of pneumoperitoneum. Alternatively, if an adnexal mass removed by using LESS is found to be malignant at intraoperative pathology evaluation, pneumoperitoneum can be easily reestablished for laparoscopic staging. Furthermore, the LESS incision can be used in a fashion similar to “mini-laparotomy” for extracorporeal performance of procedures such as partial omentectomy, repair of small bowel enterotomy, or even performance of small bowel resection with anastomosis. After these, replacement of the LESS access device can facilitate further laparoscopic work when indicated. Finally, the central location of the typical umbilical LESS incision provides equally useful access to both pelvic and upper abdominal regions. This facilitates proper thorough intraperitoneal evaluation during comprehensive surgical staging of gynecologic malignancies while minimizing potential incisional morbidity.

**Challenges of Laparoendoscopic Single-Site Surgery**

Initial development of laparoscopy entailed use of a single incision and a laparoscope that included a channel for passage of one simple tool such as biopsy forceps. MPL evolved as a means to overcome technical challenges inherent in operating through a single small incision. Although placement of multiple ports allowed for the development of more complex laparoscopic surgical procedures, there is otherwise no inherent clinical value to a use of greater number of incisions. Ongoing advances in instrumentation are now providing different solutions to these technical challenges and encourage reconsideration of the use of a single incision for laparoscopic surgery.

**Maintenance of Pneumoperitoneum**

Pneumoperitoneum is essential for performance of laparoscopy and requires an airtight seal between laparoscopic ports and the body wall. Individual ports traditionally allow passage of only one instrument at a time. To enable LESS, passage of multiple instruments must occur through one skin incision. A number of industry-developed access devices are available that overcome this challenge. Although the devices commonly available in the United States are noted here, their inclusion should not be perceived as an endorsement. Each design has strengths as well as limitations, which may or may not be pertinent depending on the needs of the surgeon and the particular case.

**FIG. 24.1** Olympus Quadport+ (Olympus America, Center Valley, Pennsylvania) consisting (from left to right) of a cap with port openings, flexible rings with an intervening plastic sleeve, and an introducer.

The Triport+, Triport 15, and Quadport+ (Olympus America, Center Valley, Pennsylvania) are single-port access devices consisting of two flexible rings with an intervening plastic sleeve (Fig. 24.1). An introducer is used to place one ring through a small incision into the peritoneal cavity. The second ring is pushed flush to the skin of the abdomen as the intervening plastic sleeve is pulled tight. The device can span a body wall incision up to 10 cm in length. An airtight, removable cap is then placed onto the outer ring. The design with respect to the cap differs in terms of number and size of available port openings. The openings are flexible and allow placement of either straight or curved instruments. There are also tubes for insufflation and gas evacuation.

The GelPOINT Advanced Access Platform (Applied Medical, Rancho Santa Margarita, California) consists of three parts: the Alexis Wound Retractor, a GelSeal cap, and several low-profile sleeves (Fig. 24.2). The wound retractor consists of two flexible plastic rings with an intervening sleeve. One ring is inserted through an incision 1.5 to 7 cm in diameter. The other ring is pulled tight to the skin by reducing the length of the intervening plastic sleeve. Once the apparatus is tightly in place on the abdominal wall, a removable Gel-Seal cap is applied. Valves for insufflation and evacuation of gas are present. Three 5- to 10-mm and one 12-mm self-retaining low-profile sleeves (ports) are included and can be placed through the gel in any desirable configuration. The GelPOINT Mini Access Platform (Applied Medical) is a similar but smaller product, accommodating incisions with diameters of 1.5 to 3 cm.

The SILS Port (Medtronic, Minneapolis, Minnesota) consists of a foam plug with four central channels (Fig. 24.3). It is placed within an incision and meant to span the body wall but is currently available in only one size (approximately 4 cm in length). Individual ports 5 to 15 mm in diameter are then placed through three of the channels. The fourth channel is used for gas insufflation.

Dedicated access devices are not necessarily required for the performance of LESS. Multiple low-profile ports can be placed through separate fascial punctures in one skin incision.
The AnchorPort Single Incision Laparoscopy Kit (SurgiQuest, Milford, Connecticut) includes three specialized 5-mm ports that “self-anchor” to the abdominal wall and “self-adjust” to the thickness of the wall. The self-adjusting design minimizes the space occupied by the port both inside and outside the incision, allowing the ports to be placed in close proximity to each other. On completion of the LESS procedure, separate fascial defects are connected, both for ease of specimen retrieval and to facilitate adequate closure.

One creative solution for maintenance of a pneumoperitoneum with passage of multiple instruments is the use of a surgical glove applied over an Alexis Wound Retractor (Applied Medical). Holes are cut in the glove fingers through which any desired laparoscopic port is placed.

**Prevention of Hand Collision**

Ensuring adequate distance between incisions in the abdominal wall is important in MPL in order to facilitate movement of the surgeon’s hands without collision. The closer the incisions are to one another, the more likely the surgeon’s hands are to collide during surgical maneuvers. LESS, by definition, forces multiple instruments to pass through a single incision. If the instruments are directed at a single surgical target, they will be parallel to each other, leading to collision of the surgeon’s hands.

Several technical solutions can assist in minimizing this problem. The design of some port systems allows for individual ports within the same incision to be located farther from each other outside the body. Regardless, they must all pass through a single fascial defect, the size of which limits the benefit of extended port spacing. Staggering the length of instruments so that hands are spaced away from each other vertically can be of assistance. Instruments with either temporary or permanent bends allow for the tips of the instruments to meet while maintaining distance between the surgeon’s hands externally (Fig. 24.4). A wide variety of disposable and a limited selection of reusable articulating instruments, including graspers, needle drivers, scissors, staplers, and suturing and energy devices, are currently available. Examples include FLEXLAP articulating instruments (Advanced Endoscopy Devices, Canoga Park, California) and Roticulator Endo Grasp and SILS Clinch graspers (Medtronic). The instruments are placed through a port while straight and then actuated to bend up to 90 degrees. Ergonomic function and ease of the instruments vary among manufacturers. Although reusable fixed-curved instruments are available (Olympus America), they can be used only with access devices that use very short port lengths. Longer straight ports will not allow passage of the curved instruments.

Standard, straight laparoscopic tools can be used to accomplish LESS, but strategies must be employed to provide space between the surgeon’s hands external to the patient. Most often,
the surgeon holds two tools passed through the LESS access device simultaneously: a dissecting and cutting tool, often energy based, and a grasper to provide tissue traction. If both are rigid, straight tools and directed at a single surgical target, the surgeon's hands tend to collide. Placement of the grasper slightly adjacent to the surgical target, for example, holding the fallopian tube medially while addressing the infundibulopelvic (IP) ligament laterally, will allow for sufficient hand separation externally. Use of these standard reusable instruments may provide cost savings and the advantage of familiarity to the surgeon compared with more complex disposable articulating tools.

Triangulation

In addition to allowing for separation between hands externally, the use of a curved or articulating instrument allows for recreation of triangulation at the surgical target (see Fig. 24.4). Taken for granted during open surgical procedures and MPL, triangulation involves approaching a surgical target with two instruments from opposing directions. This triangular relationship facilitates basic surgical technique including traction-countertraction and intricate dissection. Use of two rigid, straight instruments from a single point or incision restricts triangulation and is prone to result in external hand collision. In the same manner as described earlier, grasping tissue adjacent to the surgical target, and in a sense using the tissue as an extension of the instrument through which to provide traction at the target, may allow for successful use of straight instruments. Incorporation of a single curved or articulating instrument allows for redirection of the instrument tip within the abdomen and recreation of triangulation without external hand collision but adds cost and some degree of complexity depending on the ergonomics of the tool.

Perspective in Field of View

With the use of multiple incisions for laparoscopy, the laparoscope enters the abdomen at a site different from the site for surgical instruments. This facilitates a two-dimensional image of surgical instruments approaching the surgical target. Placement of a 0-degree laparoscope through a single incision alongside surgical instruments results in a field of view with limited two-dimensional perspective (“down-the-shaft view”). It also results in hand collision problems as described earlier.

The simplest solution to this problem is to use an angled laparoscope (e.g., 30 degree), preferably one that is longer than the other instruments in use. This facilitates movement of the camera head away from the instruments externally and vertical staggering of hands as well. Movement of the laparoscope away from the instrument shafts occurs naturally as the angled lens is used to obtain a view of the surgical field and improves the two-dimensional perspective achieved.

Flexible-tip laparoscopes, such as the Olympus ENDOEYE FLEX (Olympus) and Stryker IDEAL EYES HD (Stryker Endoscopy, San Jose, California), allow dynamic movement of the laparoscope tip in multiple directions at angles of up to 100 degrees (Fig. 24.5). This facilitates positioning of the camera driver’s hand from the surgeon’s hands while allowing the tip to be directed toward the surgical target (see Fig. 24.4). The Olympus America ENDOEYE 3D (Olympus America) provides a threedimensional image with restoration of depth perception but is currently available only with a 10-mm shaft diameter. The larger diameter shaft is less desirable with LESS because it occupies precious space within the small, single incision, reducing some of the mobility of other simultaneously passed instruments.

**FIG. 24.5** Olympus America ENDOEYE FLEX laparoscope with flexible tip.

Learning Curve

MPL requires significant training and skill development to be performed safely and efficiently. Performance of LESS is certainly not easier and may arguably be more challenging than MPL given the concerns addressed earlier. Most of the published studies concerning LESS have involved surgeons experienced in MPL. Prior expertise with MPL may facilitate acquisition of the skillset necessary for performance of LESS. The learning curve for LESS hysterectomy for a single surgeon was assessed in a study that included his first 100 consecutive procedures. A significant decrease in total operative time was noted after the first 40 cases. Stable case times thereafter prompted the authors to conclude that proficiency with LESS hysterectomy was attained after 40 cases. Given that this study represents the experience of a single experienced laparoscopic surgeon, it is unclear that the results are broadly generalizable among gynecologic oncology surgeons.

One small study of 20 medical interns with no laparoscopic experience in the operating room or with simulator training examined whether or not learning LESS is “really more difficult for the novice” than MPL. Participants performed two tasks—peg transfer and a dissection task—on a standard box trainer through either three incisions or one. They were assessed for errors and time while performing the tasks 11 times over a period of 2 days. The final scores of both LESS and MPL participants improved compared with baseline. A time plateau for both tasks was reached after an equal number of runs in both the LESS and MPL groups. An error plateau in LESS necessitated two more runs compared with MPL, but the error rate achieved at plateau was lower in the LESS group than the MPL group. These findings, albeit limited because of the small sample size and laboratory setting, suggest that skills necessary for LESS may be acquired at a similar pace compared with those for MPL. Furthermore, expertise in MPL may not be requisite before training in LESS.

**Practical Tips for Success with Laparoendoscopic Single-Site Surgery**

LESS can be challenging, even frustrating, to perform initially. Several practical suggestions may be helpful when one is working to safely incorporate LESS into gynecologic oncology practice.
Patient Selection

Medically fit patients with a favorable body habitus and no or limited prior surgical procedures should be selected when the surgeon is performing initial LESS cases. Much of the effort involved in performing initial cases will relate to port placement and understanding how to overcome the challenges described earlier. Accordingly, the procedure to be performed should be simple—for example, LESS for risk-reducing BSO. More complex procedures including hysterectomy or removal of larger ovarian masses or anticipation of need for extensive management of adhesions or endometriosis should be deferred until significant comfort with the instruments and technique has been achieved. Patients should be counseled appropriately and reassured that additional laparoscopic ports will be placed (i.e., conversion to MPL) if needed for the sake of safety or efficacy.

Orientation to Equipment

The equipment used during initial cases should be kept simple to allow skill acquisition to focus on basic principles unique to LESS: placement of an access device, arrangement of instruments within the incision, and movement of tools while avoiding external hand collision. Specialized equipment, such as articulating tools and flexible-tip laparoscopes, will result in additional learning curves. Incorporation of multiple new instruments at one time is overwhelming and may lead to a poor experience with LESS. Consistent use of one piece of equipment for a series of cases before trying numerous alternatives is recommended. Once proficiency is achieved with one instrument or approach, exploring alternatives will be useful and comparisons more meaningful. In addition, if orientation to articulating tools or a flexible-tip laparoscope is desired, consider using them during a number of MPL cases. This will allow comfort with the instrument to develop in a more familiar surgical setting. Finally, practice within a simple box trainer before live surgical use is strongly recommended.

Instrument, Hand, and Body Position

Thoughtful placement of instruments through specific port openings is essential in facilitating the desired instrument positions and tissue manipulation internally. A basic tenet is that movement of tissue toward the surgeon is best achieved by placing an instrument through the opening of the access device that is farthest away from or on the side contralateral to the surgeon. The instrument handle is then moved away from the surgeon’s body to bring tissue toward him or her. Alternatively, movement of tissue away from the surgeon is accomplished with placement of an instrument through the opening of the access device that is closest to the surgeon and by movement of the handle toward the surgeon. The instruments should be held without allowing arms or hands to cross. When at least three port openings are available to the surgeon, the lateral openings should be used for grasper placement for tissue retraction and the central opening for the operative tool (e.g., a cutting or dissecting device, suction, or scissors).

In general, placement of the laparoscope should be within the opening of the access device that is most cephalad (Fig. 24.6). In this manner, movement of the camera head externally toward the patient’s chest will both position the lens internally above the surgical field and avoid external collision with instruments held by the surgeon. The angled lens or flexible tip of the laparoscope is directed toward the surgical target below. Use of a uterine manipulator is extremely helpful for even the simplest LESS procedures. It helps provide additional retraction and movement of tissues independent from and in addition to the instruments passed through the abdominal incision. The surgical assistant is typically responsible for movement of both the laparoscope and uterine manipulator.

The patient’s arms should be tucked at the sides to allow the surgeon to stand close to the patient’s head. The surgeon’s body should be oriented relatively perpendicularly to the patient’s longitudinal axis, and the surgeon should stand on a step, if necessary, to ensure neutral position of the elbows alongside the body. The surgeon can accomplish bilateral procedures while remaining on one side of the patient, but operating from the side contralateral to the surgical target is easiest. One commonly used arrangement is for the surgeon to hold a laparoscopic instrument in each hand while standing at the patient’s right side and for the assistant to stand on the left side while holding the laparoscope with the right hand and the uterine manipulator with the left hand. Others have described the surgeon operating from above the head of the patient as a means to facilitate LESS directed toward the pelvis.11

Robotic-Assisted Laparoendoscopic Single-Site Surgery

Surgical platforms incorporating robotic assistance have become commonplace in performance of MPL. The technology within these systems that facilitates performance of MPL may soon enable a greater number of surgeons to perform LESS. Although competing platforms may be available shortly, the da Vinci Surgical System (Intuitive Surgical, Sunnyvale, California) is currently the only US Food and Drug Administration (FDA)–approved tool for RAL in the United States. The first report of robotic-assisted laparoendoscopic single-site surgery (R-LESS) in gynecology in 2009 described a risk-reducing BSO and total hysterectomy performed with standard EndoWrist instruments (Intuitive Surgical) directed through a GelPort (Applied Medical, Rancho Santa Margarita, California) at the umbilicus.42 The authors concluded that R-LESS was feasible but described several technical challenges in adapting this tool designed for MPL in a LESS approach, including robotic arm clashing (crowding), reduced triangulation, and compromised pneumoperitoneum during the procedure due to suboptimal integrity of the GelPort.

In 2014, da Vinci Single-Site instrumentation was cleared by the FDA for use in hysterectomy and salpingo-oophorectomy in benign conditions. Single-site robotic surgery aims to overcome the limitations of single-port laparoscopy by eliminating instrument clashing and reproducing conventional triangulation in a single-incision environment. These advances are achieved by using instruments with flexible shafts delivered through curved cannulas. The arc of the instruments allows them to enter
the surgical field from opposing lateral aspects, thereby recreating triangulation intracorporeally while maximizing arm separation extracorporeally (Fig. 24.7).43

Before US clearance, authors in Italy described their initial experience with the instruments in 19 women with early endometrial cancer who underwent hysterectomy and BSO compared with a group of 38 similar women in whom LESS was used.44 Median operative times were similar, no intraoperative complications were reported, and no procedures were converted to MPL. The authors acknowledged that their expertise with LESS may have limited their ability to discern an advantage for the robotic platform, but they specifically appreciated the “annulment of the annoying conflict between the instruments” with use of the robotic tool as compared with traditional LESS.

Since that early study, additional instruments including a wristed needle-driver and bipolar forceps have been introduced, further enabling performance of R-LESS. A more recent report described completion of a wide variety of gynecologic procedures including total and supracervical hysterectomy, salpingo-oophorectomy, ovarian cystectomy, and excision of endometriosis with R-LESS.45 Procedures were successfully completed in 92.5% of patients, with the need in two patients for an additional port and in one patient for conversion to traditional multiport RAL. Again, the authors conceded their own extensive prior experience with LESS but concluded that R-LESS was feasible and safe in select patients.

In a retrospective cohort study of women undergoing hysterectomy for benign indications, R-LESS was compared with LESS with 50 women in each study arm.46 No differences in complication rate, estimated blood loss, or conversion to MPL were noted. R-LESS was associated with longer operative time and earlier time to discharge from the hospital. Of note, however, all LESS cases were performed by one surgeon and predated the performance of R-LESS cases. The initial surgeon and two others performed the R-LESS cases. An evaluation of operative time by chronologic case number demonstrated a downward trend in operative time, with a more rapid decline noted with the R-LESS approach compared with LESS.

Initial studies have demonstrated the feasibility of R-LESS in the hands of experienced minimally invasive surgeons, especially those with prior LESS experience. Further studies are needed to assess whether or not the introduction and development of R-LESS will enable the performance of LESS more broadly within gynecologic oncology and to assess its possible benefits compared with both traditional multiport robotic-assisted MPL and LESS.

**Procedures in Detail**

The following sections describe key steps of procedures commonly performed with LESS in gynecologic oncology. With the exception of R-LESS, the choice of single-port access device and instrumentation is left to the discretion of the surgeon. Although placement of individual access devices differs according to manufacturers’ recommendations, most use initial abdominal access via an open, or Hasson, technique. Although the incision does not have to be umbilical, this location is assumed in the following descriptions. The principles presented earlier as practical tips for success with LESS facilitate completion of the following procedures. In general, the steps used to complete specific surgical procedures using LESS should replicate those followed in traditional MPL.

**Laparoendoscopic Single-Site Surgery Adnexectomy**

1. Placement of an intrauterine manipulator.

   An intrauterine manipulator is extremely helpful, if not essential, in the performance of gynecologic LESS procedures. The manipulator’s movement of the uterus, and tissues connected to the uterus, allows development of traction-countertraction without placement of an additional laparoscopic tool intraabdominally.

2. Abdominal access and placement of LESS access device.

3. Intraabdominal survey and peritoneal washings, when indicated.

   Extensive survey of the peritoneal cavity can be accomplished from the centrally located LESS incision, especially with the help of a flexible-tip laparoscope and changes in patient position with manipulation of the operating table. Gentle manipulation of tissues and organs with a laparoscopic bowel grasper can provide crucial four-quadrant intraperitoneal visualization.

Throughout the procedure, it should be consciously recognized that laparoscopic views with an angled or flexible-tip laparoscope are different from those seen with a 0-degree laparoscope during MPL. Although these laparoscopes help to provide suitable views and reduce external hand collision during LESS, the surgeon should vigilantly consider the ways in which these subtly different views may alter the validity of assumptions regarding visualized anatomic relationships.

Surgical instruments are placed within port openings following the basic tenets described earlier (see the sections on practical tips for success with LESS, including instrument, hand, and body positions).

4. Identification of normal pelvic anatomy and its restoration as possible.

   As in MPL, identification of critical pelvic anatomy, including ureters, sigmoid colon, and vasculature, is an essential early step in LESS. Adhesiolysis with restoration of normal anatomic relationships among structures is advised. In rare cases, the ureteral pathway along the pelvic side wall may be adequately
visualized transperitoneally. When this is not the case, retroperitoneal identification is recommended before transection of adnexal ligaments. Direction of the uterus contralateral to the pelvic side wall of interest by using the uterine manipulator assists in providing traction on the posterior leaf of the broad ligament. Medial traction directed from a grasper on the distal fallopian tube or IP ligament may aid in holding the posterior leaf taut while a generous peritoneal incision is made with a cutting tool. Similar movements of the manipulator and grasper then aid in holding the retroperitoneum open. A blunt tool such as a suction-irrigator is used to bluntly develop the retroperitoneal spaces along natural tissue plains as the ureter is identified along the medial leaf of the broad ligament.

5. Transection of utero-ovarian ligament and fallopian tube.

Conventionally during MPL, the IP ligament and ovarian vasculature are divided before division of the utero-ovarian ligament and fallopian tube at the uterine fundus. During LESS, reversal of these steps is often more ergonomic. Elevation of the adnexa out of the pelvis in a cephalad direction with traction on a grasper holding the distal fallopian tube allows clear access to the utero-ovarian ligament. Lateral movement of a similarly placed grasper to hold the IP on stretch medially may result in increased surgeon-assistant hand collision. The former approach also allows the weight of the adnexa to fall cephalad with the patient in the Trendelenburg position, assisting in providing necessary exposure. Use of the latter approach may be more challenging, especially with larger adnexa, because the weight of the ovary must be lifted away from the side wall with the sole grasper to expose the IP ligament.

6. Transection of IP ligament and ovarian vasculature.

Regardless of the sequence, care needs to be taken when transecting vasculature during LESS. Optimal use of energy tools with creation of hemostatic seals is vital. With access to fewer instruments for tissue retraction and compression, addressing unanticipated bleeding is more challenging during LESS than during MPL. Division of vascular pedicles should be performed with the pedicle off tension and skeletonized of extraneous tissue. After transection of the IP ligament, any remaining attachments between the adnexa and the pelvis are separated.

7. Removal of adnexal specimen.

During BSO for preventative purposes, the adnexa may be easily delivered through the umbilical incision without the need for a laparoscopic bag. When an adnexal tumor is present, placement within a bag before removal will reduce the risk of incisional or peritoneal contamination. A laparoscopic bag is introduced through an appropriately sized port in the access device, and the specimen is placed in the bag while pneumoperitoneum is maintained and with laparoscopic guidance. The bag opening is brought to the umbilical incision and exteriorized. The mass is then decompressed with drainage of cystic fluid until the bag can be delivered through the incision. Care should be taken to avoid puncture of the bag.

8. Removal of instruments and incision closure.

When adequate hemostasis is ensured after a short period without pneumoperitoneum, all instruments and the access device are removed. Pneumoperitoneum is easily removed via the umbilical incision. The fascia is reapproximated by using a running delayed absorbable suture such as 0-Vicryl or polydioxanone (PDS; Ethicon). Skin edges are brought together with a subcuticular stitch of material such as 4-0 Monocryl (Ethicon), and a sterile dressing is applied.

---

**Laparoendoscopic Single-Site Surgery Hysterectomy**

1. Steps 1 to 4 of LESS BSO.

These steps are repeated as necessary in preparation for LESS hysterectomy. A colpotomy cup and vaginal occluder balloon are employed, along with the uterine manipulator. Although retroperitoneal access may be gained via incision through the posterior leaf of the broad ligament, division of the round ligaments bilaterally is commonly performed. The incision is then carried cephalad to an extent depending on whether or not transection of the IP ligament and BSO are planned.

2. Transection of utero-ovarian ligament and fallopian tube.

Even if BSO is planned along with hysterectomy, it is advantageous to transect the utero-ovarian ligaments and fallopian tubes, perform the hysterectomy, and later return to divide the IP ligaments and complete the BSO. If the IP ligament is transected early and the adnexa are left attached to the uterus during hysterectomy, they may obscure necessary exposure within the posterior cul-de-sac throughout the procedure. Although an assistant grasper can easily retract the adnexa during MPL, this is not the case with LESS.


The peritoneal incision is extended through the anterior leaf of the broad ligament between the round ligaments across the anterior cul-de-sac. This incision is best made while cutting away from the surgeon. For example, if the surgeon stands on the right side of the patient, the incision is easiest when directed to the patient’s left. With this positioning, the surgeon is best served by using a grasper in the left hand placed through the leftmost port and a cutting tool in the right hand placed in the central port. The grasper is used to hold the bladder peritoneum slightly ventral and caudad within the patient while the cutting tool is directed across the anterior cul-de-sac from right to left.

The assistant should direct the uterine manipulator with the attached colpotomy cup firmly cephalad to provide clear demarcation of the cup’s position at the cervicovaginal junction. This optimizes displacement of the ureters laterally and guides the surgeon with regard to the extent of dissection necessary in preparation for colpotomy and in planning its location. Firm pressure on the colpotomy cup also provides countertraction to the surgeon’s caudad traction of the peritoneum overlaying the bladder during mobilization of the bladder off the cervix and vagina. The assistant needs to adjust the uterine position between anteverision and retroversion and between left and right direction, depending on the needs of the surgeon for both exposure and development of countertraction.

4. Skeletization and transection of uterine vasculature.

In the approach to uterine vessel transection, similar attention needs to be paid to up-front hemostasis with optimal use of energy devices during division of vascular pedicles as described in step 6 of the previous section on LESS BSO. In addition to adequate mobilization of the bladder anteriorly, incision of the peritoneum partially across the posterior cul-de-sac at or slightly above the level of the underlying colpotomy cup will facilitate skeletonization of the uterine vessels. Tissue dissection should be focused immediately at or slightly cephalad to the underlying colpotomy cup. Dissection below the level of the cup is unnecessary and endangers the ureters. If cautery without cutting is available, this should be done bilaterally before transection in order to minimize risk of backbleeding. The pedicles are then transected immediately at
the level of the underlying colpotomy cup. Gentle dissection to mobilize the pedicles slightly laterally off the cup edge ensures that they are not disturbed during upcoming colpotomy and vaginal closure.

5. Colpotomy incision.

Colpotomy incision is then made against the underlying colpotomy cup. At this time, if there is no need for retraction of nearby tissues, the surgeon may choose to manipulate the uterus with one hand and cut laparoscopically with the other. As before, if the surgeon is standing to the right, the right hand is used for the uterine manipulator while the left performs the colpotomy with a tool through the central port. If retraction of the bladder or bowel is necessary to safely complete the colpotomy, the assistant continues to manipulate the uterus. Frequent adjustments in the uterine position are important to ensure that the appropriate cutting angle is achieved between the colpotomy cup and laparoscopic cutting tool. Once detached, the uterus is removed vaginally.

6. Vaginal closure.

Pneumoperitoneum is maintained with occlusion of the vagina. Suturing during MPL is facilitated by placement of ports at different abdominal wall sites, allowing for triangulation and surgeon hand separation. During LESS, suturing with traditional laparoscopic technique is extremely difficult. Instead, the vaginal cuff can be approximated either with use of a vaginal approach or with a suturing device such as the Endo Stitch (Covidien). The Endo Stitch device is used to pass a small needle with attached suture through tissue grasped between its jaws. A knotless technique for its use with vaginal cuff closure uses application of absorbable LAPRA-TY Absorbable Suture Clips (Ethicon) to the end of a 48-inch Endo Stitch suture. The suturing device is placed through a 10-mm port opening. With the surgeon to the right of the patient, the right hand is used to control the device. The left hand may be used with a grasper through a leftward port opening to retract tissues away from the vaginal edges. The first pass of suture is placed from out to in through the vagina on the lower left side of the cuff. The device is removed, and the entire suture is pulled so that the LAPRA-TY clips at its end pull against the cuff. A portion of this length of suture is then held outside the abdomen by the assistant to provide upward traction on the cuff. The device is reintroduced, and the suture is passed from in to out through the upper left side of the cuff. Again the device is removed, and the suture is pulled taut. From this point, the suture is passed through the anterior cuff outward to and through the posterior cuff inward to out. With each full-thickness bite and approximation, the device is removed, and the suture is pulled taut. This proceeds from left to right, back in the direction of the surgeon standing on the right. The suture held taut by the assistant serves in the role of an additional tissue grasper. On completion of the length of the cuff, LAPRA-TY Absorbable Suture Clips are applied to the end of the suture against the cuff, and the remaining suture is cut.

7. Completion of BSO (if indicated and not previously performed with hysterectomy).

See steps 6 and 7 in the previous section on LESS BSO.

8. Removal of instruments and incision closure.

See step 8 in the previous section on LESS BSO.

Laparoendoscopic Single-Site Surgery Staging Lymphadenectomy

Staging lymphadenectomy is usually performed concurrently with hysterectomy and BSO in women with endometrial or ovarian cancer. It may be performed independently when staging was not performed during an initial procedure or concurrently when a fertility-sparing approach is desired in young women with an ovarian cancer that clinically appears confined to a single ovary. The steps for LESS hysterectomy and adnexitomy are described earlier, parts or all of which would be performed in preparation for LESS staging lymphadenectomy.

**Pelvic Node Dissection**

1. Orientation and exposure of the surgical field.

The patient is placed in the steep Trendelenburg position. Folding the small bowel and rectosigmoid colon gently out of the pelvis withatraumatic graspers optimizes pelvic exposure. Dissection is easiest to perform with the surgeon standing on the side contralateral to the targeted pelvic side. The flexible-tip laparoscope is directed so that the external iliac vessels are viewed horizontally, similar to the view seen during open pelvic lymphadenectomy.

2. Identification of key structures and development of retroperitoneal spaces.

If not already performed as part of a concurrent operation, an incision is made through the peritoneum of the posterior leaf of the broad ligament, parallel to the external iliac vessels. Key anatomic landmarks are identified on each pelvic side. These include the bifurcation of the common iliac artery into its external and internal branches, their respective courses along the pelvic side wall along with their associated veins, the circumflex iliac vein as it crosses the external iliac artery, the superior vesical artery, the genitofemoral nerve, and the path of the ureter along the medial leaf of the broad ligament. The medial leaf of the broad ligament and the superior vesical artery are held medially while the paravesical and pararectal spaces are gradually developed by using gentle, blunt dissection. Careful medial traction against the external iliac vein facilitates separation of nodal material from the lateral pelvic side wall in an avascular plane. The genitofemoral nerve should be left lateral to the dissection in its position along the psoas muscle. With thorough development of these avascular planes, the majority of the lymph node packet is freed of medial and lateral pelvic attachments.

3. Separation of nodal material from the iliac vessels and obturator nerve.

Dissection of the nodal bundle from the iliac vessels is achieved with use of a blunt grasper to hold tissues and the nodal bundle medially and a multifunctional 5-mm laparoscopic instrument to hemostatically seal small vessels and transect vascular and connective tissues. The dissection is initiated lateral to the external iliac artery. The external iliac vessels are skeletonized of the fatty and lymphatic tissues from a lateral to medial direction. The dissection should proceed gradually along the entire length of the vessels in a manner that allows the nodal material to fold medially off the vessels. With sufficient prior development of the retroperitoneal spaces and identification of key pelvic structures, the bundle should be relatively easy to mobilize. Before a cutting tool is used within the obturator space, the obturator nerve should be identified and its course carefully mapped. Once identified, the nodal bundle can be peeled cephalad off the underlying nerve. A blunt tool such as the suction irrigator is often useful in performing these maneuvers.

4. Extraction of nodal material.

The excised nodal tissue is placed in an endoscopic bag and retrieved through the umbilical incision. Alternatively, the bag may be left in the pelvis while the contralateral pelvic nodal
Chapter 24 Laparoendoscopic Single-Site Surgery in Gynecologic Oncology

Paraortic Node Dissection

1. Orientation and exposure of the surgical field.
   
   The patient is placed in the steep Trendelenburg position. A semi–flank tilt may be useful to aid in exposure of the aorta. The small bowel and omentum must be folded into the upper abdomen. Although exposure to the level of the duodenum is not anticipated throughout the entire procedure, it will be necessary during the more cephalad portion of the operation. Given the lack of multiple laparoscopic instruments for retraction during LESS, retraction of tissues may present more of a challenge than when performing paraaortic dissection with a multiport approach. Sufficient exposure may require a marionette retraction technique wherein the small and/or large bowel is held out of the surgical field with a temporary suture placed between the bowel mesentery or epiploica to strategically located peritoneum of the abdominal wall.

   Positioning of the surgeon and assistant can occur in a variety of ways. Initial performance of paraaortic dissection should replicate as best as possible the laparoscopic views and instrumentation that each individual surgeon is accustomed to with MPL. For example, a flexible-tip laparoscope held by an assistant standing to the left of the patient, positioned so that the aorta is relatively vertical on the monitor, replicates the view many surgeons see during a robotic-assisted paraaortic lymphadenectomy. The view is rotated to position the aorta more horizontally if desired. In this arrangement, the surgeon would remain on the patient’s right side while dissecting both the left and right nodal bundles. The surgeon should be standing very tall over the abdomen, with the table height low, and standing on lifts if necessary. Surgical effort will be directed nearly vertically under the umbilical incision. This tall positioning will aid in keeping the surgeon’s elbows near the sides and his or her shoulders relaxed.

2. Right-side dissection.
   
   An incision through the peritoneum overlying the right common iliac artery is made parallel to the vessels and extends cephalad over the aorta. The incision should begin cephalad to the location of the right ureter passing over the common iliac artery. The lateral cut peritoneal edge is held laterally while blunt dissection is used to mobilize the ascending colon and its mesentery along with the underlying right ureter laterally. This mobilization extends at least to the level wherein the right gonadal vein drains into the vena cava.

   Release of right-side nodal material is then achieved with careful separation of it from the vena cava and aorta using instruments and techniques similar to those described for pelvic lymphadenectomy. Dissection is best performed in from caudad to cephalad in direction, beginning near the upper limit of the pelvic dissection and extending to the desired cephalad landmark. The nodal bundle is gradually folded cephalad and medially off the underlying vena cava with traction on the bundle, both medial and ventral, by using a grasper. Once isolated, the bundle is placed in an endoscopic bag and placed in the pelvis for later retrieval.

3. Left-side dissection.
   
   Maintaining the same position for the surgeon and assistant, the flexible-tip laparoscope is positioned to allow the aorta to be viewed at a diagonal with the cephalad area to the lower left on the monitor. The degree to which the aorta is viewed vertically or horizontally will depend on surgeon preference. Exposure of the left-side nodal basin begins with development of the avascular plane between the mesentery of the descending and rectosigmoid colon ventrally and laterally below the level of the bifurcation of the inferior mesenteric artery (IMA) off the aorta. The left ureter is identified and mobilized together with the colonic mesentery.

   Exposure of the nodal material should begin from near the upper border of the left pelvic lymphadenectomy and gradually move cephalad. Dissection is primarily blunt and with similar instrumentation as with the right side. Although many surgeons extend their left-side dissection only as high as the IMA, with appropriate retraction of bowel and mesentery, potentially with marionette sutures, the nodal bed may be exposed up to the level of the left renal vein.

   Once the nodal bundle is fully exposed and separated from all but the aorta and the underlying vertebral connective tissues, dissection should proceed from caudad to cephalad, medial to lateral. As with the right side, the bundle is gradually folded cephalad. If desired, the bundle above and below the IMA may be taken separately. The isolated lymphatic bundle is placed in an endoscopic bag and, along with the previously bagged right-side nodes, retrieved through the umbilical incision. After removal and a short period of desufflation, the abdomen is re-insufflated and the dissection beds are irrigated with sterile water and inspected to ensure hemostasis.

4. Extraperitoneal approach to paraaortic lymphadenectomy.

   Extraperitoneal staging via LESS by using a single incision near the left iliac crest is also feasible with conventional laparoscopic tools. A detailed presentation of this approach has been previously published. Exposure of the paraaortic region is excellent with this technique because bowel and other peritoneal tissues are completely avoided.

Robotic-Assisted Laparoendoscopic Single-Site Hysterectomy and Bilateral Salpingooophorectomy

A 2.5-cm skin incision at the umbilicus is required, with the Hasson technique used for intraperitoneal access. Port placement is similar to that of the SILS Port (Medtronic), with the exception that the material is much more delicate and will fracture easily. Therefore the port should be “fed” incrementally into the incision by using a curved clamp, with care taken to slide rather than drag the port into place.

   Insufflation can begin after port placement and gas egress are minimal, even in the absence of trocars. The camera trocar is placed, and the robot is center docked. Under direct visualization the short curved cannulas are placed, arm 2 before arm 1, with the trocar concavity facing the midline. Within the port, the cannula channels cross. Therefore, in placing a cannula, the tip will come into view on the contralateral side (Fig. 24.8).

   While handedness is maintained at the console (i.e., the surgeon’s right hand controls the instrument tip field right), note that arm 2 (the patient’s left) holds the instrument in field right, and arm 1 (the patient’s right) holds the instrument in field left. Side docking is feasible; however, doing so limits the range of motion on the contralateral side. For most purposes, center docking is preferred.

   Total robotic-assisted hysterectomy and oophorectomy are feasible FDA-approved applications of single-site robotics.
Pelvic lymphadenectomy or sentinel node mapping and resection are feasible off-label applications of the platform for select candidates or research institutional review board–approved protocols. Typical instrument configuration includes the monopolar hook or shears in the dominant hand and a bipolar grasper or sealer in the nondominant hand. However, the optimal configuration is dependent on the comfort and experience of each surgeon.

Successful single-site robotic hysterectomy recapitulates the technique of the open and laparoscopic approaches. The round ligament is divided, and the retroperitoneal spaces (paravesical, pararectal) are developed as needed to skeletonize the gonadal vessels and visualize the ureter. The vesicouterine peritoneum is opened, and the bladder is reflected away from the lower uterine segment and cervix. The uterine arteries are skeletonized, coagulated, and divided. Posteriorly, the peritoneal incision is continued, dividing the uterosacral ligaments, taking care to avoid the ureters laterally and the rectum posteriorly. The colpotomy is performed, and cuff closure can be achieved vaginally or robotically with the wristed single-site needle driver.

**Conclusion**

Numerous comparison series and three randomized controlled trials have suggested reduced postoperative pain, less need for analgesic use, and improved cosmetic results when LESS is compared with MPL in performance of a wide variety of gynecologic surgical procedures. The retrospective design and small populations examined in the majority of these studies limit the strength of current conclusions. In contrast to the benefits of MPL compared with laparotomy, which are relatively marked, small, albeit clinically significant, benefits of LESS compared with MPL may be more difficult to demonstrate with statistical significance. Regardless, the argument that additional incisions and trocar stabs contribute to beneficial patient outcomes seems untenable when they are not technically necessary for safe completion of a surgical procedure.

Currently available literature has demonstrated the feasibility of LESS for the majority of surgical procedures performed in the practice of gynecologic oncology. The potential for reduced pain and other incisional morbidity should prompt consideration of this approach when any laparoscopic operation for management related to gynecologic malignancy is being planned. LESS may be particularly advantageous when removal of a mass is anticipated. The potential benefits of LESS justify further development of surgical instrumentation and educational programming directed at overcoming barriers to the adoption of this approach by motivated surgeons. Common sense dictates that laparotomy incisions should be only as large as necessary to provide for performance of safe and effective surgery. This same common sense directed toward laparoscopy should prompt serious consideration of the merits of LESS.

**Conflicts of Interest**

Dr. Boruta has no conflict of interest to declare. Dr. Escobar has no conflict of interest to declare.

**Acknowledgment**


**References**

Chapter 24 Laparoendoscopic Single-Site Surgery in Gynecologic Oncology


The use of laparoscopy has been implemented in the management of adnexal masses since the late 1970s. However, laparoscopy became more popular in gynecologic oncology after Daniel Dargent first described the use of this technique to evaluate pelvic lymph nodes in 1989. A few years later, Querleu and colleagues described the first cases of laparoscopic pelvic lymphadenectomy in patients with cervical cancer. It did not take long for other laparoscopic procedures to prove feasibility through many retrospective and prospective studies. A survey among the members of the Society of Gynecologic Oncology (SGO) evaluated the current patterns of use of minimally invasive procedures, including traditional laparoscopy, robotic-assisted surgery, and single-port laparoscopy. That study showed that in the past decade the indications for minimally invasive surgery have expanded beyond endometrial cancer staging to include surgical management of early-stage cervical and ovarian cancers; in addition, the researchers found that the use of single-port laparoscopy remains limited.

For endometrial cancer, a minimally invasive approach is already considered the gold standard. The Gynecologic Oncology Group (GOG) study LAP2, the results of which were published in 2009, is considered the turning point for the use of laparoscopy in endometrial cancer. Patients with clinical stage I to IIA uterine cancer were randomized in 2:1 fashion to undergo comprehensive surgical staging via either laparoscopy (n = 1696) or laparotomy (n = 920). Laparoscopy was significantly associated with fewer moderate and severe postoperative complications compared with laparotomy (14% vs. 21%, respectively) and similar rates of intraoperative complications. The incidence of hospitalization of more than 2 days was significantly lower compared with laparotomy (52% vs. 94%). Better quality-of-life measurements in the laparoscopy arm at 6 weeks compared with the laparotomy arm were statistically significant, including higher Functional Assessment of Cancer Therapy—General (FACT-G) scores, better physical functioning, better body image, less pain and its interference with quality of life, and an earlier resumption of normal activities and return to work. The overall recurrence rates were low and very similar in the laparoscopy and laparotomy arms (11.4% and 10.2%, respectively). The GOG LAP2 study also reported an estimated 5-year overall survival rate that was almost identical in both arms at 89.8%.

One of the potential disadvantages of the laparoscopic approach is the longer operative time (median, 204 vs. 130 minutes). Conversion to laparotomy occurred in 25.8% of the laparoscopic cases, primarily because of poor exposure, metastatic cancer, bleeding, older age, or high body mass index (BMI). This high rate of conversion was also probably related to the learning curve for surgeons. Inexperienced surgeons were allowed to participate, and no quality control for the laparoscopists or the laparoscopic procedure was performed. Such a high rate of conversion would be unacceptable today, and the more current range of conversion is approximately 5%. Thus it is reasonable to believe that the results of GOG LAP2 would be even more in favor of laparoscopy compared with laparotomy nowadays.

Laparoscopy has been proven to have the same overall survival, disease-free survival, and cancer-related survival rates compared with those of laparotomy, with significantly lower blood loss and lower postoperative complications without significant difference in yield of pelvic and paraaortic nodes. The laparoscopic approach also involves a shorter hospital stay, less pain, and faster resumption of daily activities. These benefits are most associated with laparoscopy and are extended to nearly all fields of surgery.

In the area of cervical cancer, laparoscopic radical hysterectomy was initially described in 1992 by Nezhat and colleagues. The benefits of laparoscopic radical hysterectomy, compared with open radical hysterectomy, reflect the general benefits of laparoscopy—in particular, decreased hospitalization, reduced blood loss, faster recovery, diminished overall hospital charges, and less postoperative pain.

For patients with ovarian cancer, the accuracy and adequacy of surgical staging by laparotomy or laparoscopy appear to be comparable, with neither approach conferring a survival advantage. As usual, laparoscopy offers lower postoperative complication rates, shorter postoperative hospital stay, and less blood loss. However, intraoperative tumor rupture has been reported to occur more frequently in patients undergoing laparoscopy compared with laparotomy in retrospective cohort studies. There are no randomized data comparing laparotomy and laparoscopy staging for ovarian cancer.
Preoperative Evaluation

When considering patients for laparoscopic surgery, one needs to consider many of the same criteria as for open procedures. However, one also needs to keep in mind that patients will need to be placed in the Trendelenburg position and that they will need to be able to tolerate a consistent level of increased intraabdominal pressure for several hours during the operation. Patients with a history of heavy smoking or documented pulmonary disease, particularly chronic obstructive pulmonary disease (COPD), are at higher risk for conversion to an open procedure. During laparoscopy, increased intraabdominal pressure shifts the diaphragm cephalad and reduces diaphragmatic excursion, resulting in the early closure of smaller airways, leading to intraoperative atelectasis with a decrease in functional residual capacity. In addition, the upward displacement of the diaphragm leads to the preferential ventilation of nondependent parts of the lungs, which results in ventilation-perfusion mismatch with a higher degree of intrapulmonary shunting.

Smoking is a well-known risk factor for pulmonary disease but not necessarily a risk factor for pulmonary complications. Graybill and colleagues reported a rate of pulmonary complications of 2.1% in “never smokers,” 4.5% in past smokers, and 0% in current smokers after laparoscopic gynecologic surgery. Thus, smoking history did not appear to affect postoperative pulmonary and upper respiratory complications and should not be a contraindication to laparoscopy.

In the patients with advanced COPD, the combination of ventilation-perfusion mismatch, decreased gas transfer, and alveolar hypoventilation ultimately leads to respiratory failure. When this condition is associated with physiologic changes previously mentioned, the patients are more susceptible to barotrauma or volutrauma, hypercapnia, and acidosis. In general, these patients still benefit from laparoscopic surgery because it reduces the risk of postoperative pulmonary infection. A baseline arterial blood gas measurement may be useful in predicting high-risk patients, with both Paco2 above 5.9 kPa and PaO2 below 7.9 kPa predictive of a worse outcome. Spirometry is useful to confirm the diagnosis and to assess the severity of COPD, thus allowing identification of patients at risk for conversion. To avoid conversion in these patients, intraabdominal pressure should be maintained at less than 10 mm Hg (usually 8 mm Hg), and constant communication with the anesthesiologist should be maintained to address any adverse outcomes.

Patients with cardiac diseases are at risk for laparoscopic complications. The pneumoperitoneum may induce hypertension because of the increased afterload by vasoconstriction and release of catecholamines. The increased afterload and tachycardia are associated with increased myocardial workload, predisposing to ischemia. Elevated intrathoracic pressure reduces venous return, decreases preload, and reduces end-diastolic volume. Such changes, even when temporary, can cause decreased cardiac output, exacerbating heart failure, myocardial ischemia, and arrhythmias. In addition, the Trendelenburg position may also worsen cardiac function. In a study by Falabella and colleagues in patients who underwent robotic-assisted prostatectomy, the investigators confirmed that patients in a steep Trendelenburg position have increased venous return, increased preload, and increased myocardial wall stress. Still, laparoscopy was safe among patients with congestive heart failure undergoing general surgical procedures and seemed to have a protective effect against mortality, if their heart condition was optimized before operation.
Tumor Manipulation, Tissue Extraction, and Port-Site Metastasis

Port-site metastases (PSMs) occur in approximately 1% of patients who have undergone laparoscopic procedures for a malignant disease. Ninety-five percent of patients have simultaneous carcinomatosis or metastases to other sites at the time of PSM diagnosis. The incidence of PSM after laparoscopy for cervical and endometrial cancer is less than 0.5%, and most of the time it is also associated with carcinomatosis. Abdominal wall metastases are not limited to laparoscopy and are observed with similar frequency in laparotomy procedures. The exact mechanism of how PSMs occur is still not completely understood. Theories involve the exfoliation and spread of tumor cells by laparoscopic instruments; direct implantation at the trocar site by frequent changes of instruments; direct implantation from the passage of the specimen; the impact of aerosolization of cancer cells by the pneumoperitoneum, which when released can create a “chimney effect” that causes an increase in the passage of tumor cells at port sites; and preferential growth of malignant cells at areas of laparoscopic peritoneal perforation. Local immune reaction and tissue trauma have also been proposed as causes of PSMs in experimental models.

Several rules should be followed to avoid PSM, including avoiding tumor manipulation and unprotected tumor extraction. One should aim to remove lymph nodes or other potentially malignant tissue through the trocars with an endoscopic bag. Zivanovic and colleagues published findings from the largest series of PSMs, including 1694 patients with malignant intraabdominal conditions. PSMs were documented in 20 patients (1.18%). Of these, 15 had a diagnosis of epithelial ovarian or fallopian tube carcinoma. Nineteen of 20 patients (95%) had simultaneous carcinomatosis or metastases to other sites at the time of PSM.

Video 25.8 shows several techniques used for tissue extraction in order to avoid rupture. The incision used for extraction must have an adequate length; it is a common mistake to create a small incision and then use excessive traction, which can cause rupture of the bag and potential spillage of the tissue. Frequently, enlarging the incision 1 or 2 cm is enough to allow easy extraction and also saves time.

The chimney effect is also considered a possible cause of PSM. This refers to the increase in the number of tumor cells at the port sites caused by leakage of gas along the trocars. It is possible that gas turbulence favors the embolization of exfoliated tumor cells during dissection to the trocar sites. The gas-containing tumor cells can leak during the procedure between the port cannula and the abdominal wall and also at the end of the procedure if the gas is evacuated through the port incision after the trocar has been removed. Therefore we recommend that surgeons evacuate the gas and fluids before pulling out the ports.

Based on experimental models, port-site lavage with povidone-iodine has been suggested as a method to reduce PSM. Using colon cancer cells in a rat model, Eshraghi and colleagues showed that irrigation of the port site with 5-fluorouracil significantly decreased the incidence (30% vs. 81%) of metastases. In another study, Neuhaus and colleagues randomly allocated rats into five groups: (1) control (no intraperitoneal instillation), (2) intraperitoneal normal saline, (3) intraperitoneal povidone-iodine solution, (4) intraperitoneal methotrexate, and (5) intramuscular methotrexate. A significant reduction in tumor implantation and PSMs was observed in all treatment groups.

No study in which port-site lavage was used with humans is available to date.

Ramirez and colleagues have suggested a series of preventive measures to reduce PSM (Box 25.1).

**Patient and Operating Room Setup**

In laparoscopy, patient positioning and trocar placement are crucial, and their importance should never be underestimated. We recommend that surgeons always position the patient themselves, and all attempts should be made not to delegate this task to operating room personnel. The patient is placed in a dorsal modified lithotomy position for most laparoscopic pelvic procedures (Fig. 25.1). Given that the patient will be in a steep Trendelenburg position during pelvic procedures, it is important to ensure that the patient is properly secured to the table, especially obese patients, to avoid sliding and accidents. This can be accomplished by using a foam pad fixed to the table under the patient. Pneumatic intermittent compression devices are placed; the patient’s legs must be ab ducted enough to allow uterine manipulation. For pelvic surgeries, the thighs are flexed over the abdomen, but during retroperitoneal or upper abdominal procedures they must be flat (180 degrees to the torso) to avoid interference between the surgeon’s hand and the patient’s thighs. Even in patients who have previously undergone hysterectomy, perineal access is suggested in case a vaginal or rectal probe is needed, as well as for cystoscopy or rectal stapler insertion. As a reference, we use the distal segment of the sacrum for adequate placement because it allows full uterine mobilization with the manipulator and also allows insertion of a rectal stapler, if necessary.

As the last step of the positioning, the patient’s arms are placed alongside the body. The surgeon must ensure that the arms are properly padded to avoid ischemia, obstruction of venous access, and misplacement of oximeter or blood pressure measurement devices. Leaving the arms extended is not routinely recommended because it may interfere with mobility of the surgeon for adequate pelvic dissection. Once the patient has been positioned, the urinary catheter is placed and the uterine manipulator is inserted. In case of sentinel lymph node dissection, injection of the tracer must be performed before cervical dilation. The exception to manipulator insertion is a patient who is a candidate for tracheectomy with macroscopic tumor; a manipulator is not recommended for such patients, but a vaginal
probe may be used if needed. Some surgeons avoid the use of a uterine manipulator in cervical cancer patients with macroscopic tumor. For standard positioning, the surgeon is on the patient’s left side, the first assistant is on the right, the second assistant is between the patient’s legs holding the uterine manipulator, and the scrub nurse is lateral to the patient’s left leg (Fig. 25.2).

**Trocar Placement**

In a prospective randomized trial comparing Veress needle use, direct trocar insertion (DTI), and open technique, minor complications occurred in 36 (6%) of 595 consecutive procedures: extraperitoneal insufflation (n = 6 in the Veress needle group only); site bleeding (n = 2 in the Veress needle group, n = 2 in the DTI group, and n = 1 in the open technique group); port-site infection (n = 5 in the Veress needle group and n = 6 in open technique group); and omental injury (n = 6 in the Veress group and n = 3 in the DTI group). Failed entry occurred in four patients in the Veress needle group and one patient in the DTI group. Mean times of entry were 212.4, 71.4, and 161.7 seconds for the Veress needle, DTI, and open technique groups, respectively. Among major complications, one bowel injury resulted from the Veress needle technique.

As result, DTI and open technique entry presented a lower risk of minor complications and were faster compared with the Veress needle technique.

A Cochrane review including 46 randomized controlled trials (7389 patients) evaluated 13 laparoscopic entry techniques. The study failed to show evidence to recommend one laparoscopic entry technique over another. Even techniques such as the use of radially expanding trocars versus non-expanding trocars, or direct-vision entry versus open-entry, did not have significant differences in terms of complications. There was a significantly higher risk of failed entry in the group in which the abdominal wall was lifted before Veress needle insertion than in the not-lifted group (odds ratio [OR], 4.44; 95% confidence interval [CI], 2.16–9.13; n = 150). The studies had small numbers and excluded many patients with previous abdominal procedures and women with a high BMI. Some might suggest that the open technique should be used in the case of previous incision in the vicinity of the first trocar site. In patients with a midline vertical incision, surgeons should consider the Palmer point in the left upper quadrant. All auxiliary trocar insertion must be performed under direct visualization.

The chapter authors’ standard trocar placement (also known as French positioning) is as follows: a 10- to 11-mm port is inserted in the umbilicus, and two 5-mm ports are placed approximately 2 cm medial and cranial to the anterior superior iliac spine. A third 5-mm port is inserted 8 to 10 cm below the umbilical one on the midline (Fig. 25.3). For paraaortic lymphadenectomy, a 10-mm suprapubic trocar can be used, and the umbilical port is usually inserted in the cranial part of the umbilicus (Fig. 25.4). Additional ports should be considered if standard port placement does not provide adequate access to the site of interest.

The use of very low suprapubic port placement for cosmetic reasons is discouraged, as is use of only two ports for manipulation, because these practices are not ergonomic and can compromise the safety of the procedure as traction and countertraction will be compromised. In women with a large uterus (>500 g), when vision is impaired because the large volume of the uterus blocks the camera, the camera trocar may be placed 3 to 5 cm more cranial than the usual position in the umbilicus. Trocar fixation with sutures is advised to avoid frequent accidental removal and re-insertion, especially for prolonged procedures.
There are several techniques for removing the trocars. One may opt to remove the trocars after the abdomen has been deflated; others prefer to remove the trocars while the abdomen is still insufflated. Removal while the abdomen is insufflated allows for visualization of the trocars as they are removed and will help in showing whether there is any evidence of bleeding from the sites. Removal after the abdomen has been deflated offers the advantage of avoiding the chimney effect, which in the setting of cancer may contribute to the development of PSMs.

**Abdominal Exploration (Video 25.1)**

As in all oncologic surgical procedures, the first step is always complete abdominal cavity exploration. Clockwise inspection is recommended, starting with the pelvis and following with the appendix, cecum, right colon, right liver and diaphragm, left liver and diaphragm, stomach, and left colon and finally the sigmoid. One should then perform inspection of the terminal ileum, jejunum, mesentery, omentum, and finally the transverse colon and its mesentery. For pelvic procedures, the patient is placed in the Trendelenburg position, and the bowel is mobilized into the upper abdomen.

If peritoneal disease is found during this first inspection, then a more extensive evaluation must be performed, including the lesser sac, hepatic hilum, and cranial surfaces of the liver and spleen; comprehensive mesenteric inspection; and inspection of any other peritoneal surface that might contain peritoneal implants. This can be accomplished by using a 45-degree scope and extra port insertion for better organ mobilization. Patient positioning is also an important factor that allows full abdominal exploration.

**Total Laparoscopic Hysterectomy (Video 25.2)**

Total hysterectomy (simple hysterectomy) is the most frequently performed procedure for gynecologic malignancies. Several studies and meta-analyses have shown that laparoscopic hysterectomy, with or without other staging procedures, is as safe as the open approach in terms of complications and oncologic outcomes.\(^6,7,9\) Laparoscopic hysterectomy has some advantages over abdominal hysterectomy, including more rapid recovery, fewer febrile episodes, and fewer wound or abdominal wall infections, but these are offset by a longer operating time.\(^36\)

**Exposure of the Retroperitoneum**

The operation starts with the sealing and cutting of the round ligament midway from the uterus and the pelvic side wall. The former helps to expose the round ligament by using traction, and the uterus is retracted contralaterally by the second assistant with the uterine manipulator. The anterior leaf of the broad ligament is opened until it reaches the uterus. Traction is used to dissect the posterior leaf of the broad ligament. The uterus is then identified on the medial leaf of the broad ligament. The uterine may be identified transperitoneally or retroperitoneally. An incision is then made in the posterior leaf of the broad ligament close to the infundibulopelvic (IP) ligament, above the uterine, creating a window (Fig. 25.5).

**Salpingectomy and/or Adnexectomy**

If the ovaries are going to be preserved, then the mesosalpinx is cut throughout the utero-ovarian ligament to avoid ischemia of the ovary. At this point, the utero-ovarian ligament is sealed and cut (see Fig. 25.5). Care must be taken not to cut the utero-ovarian ligament in close proximity to the uterus. In this area the vessels are tortuous, and if the transection is made too close to the uterus, there may be significant bleeding from the uterus.

In the setting of performing adnexectomy, the IP ligament is placed under traction by the first assistant while the surgeon coagulates and cuts it. Hemostasis of the distal end of the IP ligament is as important as that at the proximal end because backflow in the uterus is a common cause of bleeding during surgical procedures.

**Posterior Leaf and Uterosacral Ligament Section**

The posterior leaf of the broad ligament is dissected medially until the uterosacral ligament is reached, while the second assistant pushes the uterus anteriorly and laterally and the first assistant holds the round ligament (Fig. 25.6). The same steps are repeated on the opposite side.

**Vesicouterine Space Dissection**

Vesicouterine space dissection begins with the second assistant pushing the uterus centrally. The first assistant grasps the bladder with atraumatic forceps. It is important at this point that careful attention be paid to the traction that is placed on the bladder peritoneum because excessive traction may cause an accidental cystotomy. The assistant uses anterior traction to expose the vesicovaginal fold while the surgeon cuts the peritoneum along its junction to the uterus, connecting the two previously dissected anterior leaves of the broad ligament.
Chapter 25 Laparoscopic Approach to Gynecologic Malignancy

The Laparoscopic Approach

is an ongoing phase 3 pro-

Ject. Then the pericervical fascia is incised at the

same level of the coagulated uterine pedicles to enter the fas-

cial plane. The paracervical vessels and the insertion of the

uterosacral ligament are coagulated and transected until the

surgeon has a full vaginal circumference accessible for cutting.

Transection of Uterine Vessels

The uterine pedicles must be isolated to allow effective coagu-

lation. However, the vessels should not be individually dis-

sected because this is a common cause of bleeding. The uterine

vessels are coagulated along their junction to the cervix and

cut (Fig. 25.7). Then the pericervical fascia is incised at the

same level of the coagulated uterine pedicles to enter the fasci-

al plane. The paracervical vessels and the insertion of the

uterosacral ligament are coagulated and transected until the

surgeon has a full vaginal circumference accessible for cutting.

Colpotomy and Uterine Extraction

The vaginal junction of the cervix can be appreciated while the

assistant pushes the valve and uterus to the contralateral side;

the surgeon is able to cut the vagina by using monopolar energy.

The use of cutting energy is advised in order to minimize tis-

sue trauma and to allow better vaginal healing. Air leakage is

avoided by using a vaginal occluder with the manipulator. Air

leakage must be controlled to avoid unintentional lesions of the

rectum during posterior colpotomy.

The uterus is extracted vaginally if size permits. Usually, a

uterus up to 350 g is easily extracted through the vagina. Mor-

cellation is not advised in patients with gynecologic tumors; it

can be considered when it is not feasible to remove the uterus

intact, but it must be performed by using an extraction bag.

Vaginal Cuff Suture

Usually the vaginal vault is sutured with separate zero monofil-

ament absorbable sutures; however, suture techniques and mate-

rials vary among the surgeons. Vaginal cuff closure may be one

of the most challenging steps during laparoscopic hysterectomy.

There are several techniques and tools that may be used to per-

form vaginal cuff closure, and all are effective provided proper

technique is used. We prefer to use barbed sutures because these

allow for faster and easier closure. In addition, they may also

reduce the rate of vaginal cuff dehiscence (VCD).43

Laparoscopic Radical Hysterectomy

Nezhat and colleagues17 first described the laparoscopic radical

hysterectomy in 1992. The indications for laparoscopic radical

hysterectomy are the same as for the open approach. The most

common indication for radical hysterectomy is the diagnosis of

cervical cancer stage IA1 with lymphovascular space invasion or

IA2 to IB1 and selected cases of II A1 disease. For tumors smaller

than 2 cm, the type B radical hysterectomy (Querleu and Mor-

row classification)44) is considered adequate. It also can be used

in endometrial cancer with stromal invasion of the cervix. For

cervical cancers larger than 2 cm, the type C1 radical hystere-

ctomy is the preferred approach.

Retrospective studies have shown that compared with the

open approach, laparoscopic radical hysterectomy reduces

operative blood loss, postoperative infectious morbidity, and

postoperative length of stay, but it is associated with increased

operative time.18,19,45 Surgical time for laparoscopic radical hyste-

rectomy has ranged from 92 to 344 minutes.45,46 The conver-

sion rate is approximately 1.5%.47 The Laparoscopic Approach

to Cervical Cancer (LACC) study is an ongoing phase 3 pro-

spective randomized clinical trial48 comparing open with laparo-

scopic or robotic radical hysterectomy in the management of

patients with early-stage cervical cancer. The end points of

the study include progression-free and overall survival, feas-

ibility of lymphatic mapping, and quality-of-life outcomes. The

study has stopped recruiting recently, and its results are pend-

ing. Despite the lack of large randomized studies, it is sug-

gested that the recurrence rate is equivalent to that of the open

technique.46,49,50

Laparoscopic Type A Radical Hysterectomy

(Extravascular Hysterectomy)

The steps of this procedure are the same as those for a

simple hysterectomy until the paracervix transection. The posi-

tion of the ureters is determined by palpation or direct visual-

ization (after opening of the ureteral tunnels) without freeing the

ureters from their attachments to the broad ligaments.51 The uterine

vessels are coagulated and cut between

the ureter and the cervix. After the transection of the uter-

ine vessels, the uterosacral ligaments are transected at the

same level. Then the pericervical and perivaginal tissues are

coagulated and cut to allow complete extravascular resection of

the cervix.

The vaginal section is performed in the same manner as for

total hysterectomy, except for the inclusion of a small cuff, usu-

ally less than 10 mm, of the vagina. The uterus is extracted vagi-

nally, and hemostasis of the pericervical tissue is performed by

using bipolar energy. Vaginal closure is performed as in total

hysterectomy, and oophoropexy can be performed if needed.

The operation concludes with cavity inspection for abnormal

secretion or bleeding, followed by irrigation of the remaining

pelvic cavity.
Laparoscopic Type B Radical Hysterectomy (Video 25.3)

The type B radical hysterectomy is also called a modified radical hysterectomy. The operation starts with the sealing and cutting of the round ligament at the point where this enters the inguinal canal. This step is performed while the uterus is mobilized contralaterally by using the uterine manipulator. The peritoneum along the lateral aspect of the external iliac artery is incised. This peritoneal opening is extended proximally along the artery and the IP ligament but lateral to these structures. Gas infiltration of connective tissue helps in visualizing the dissection of this space. The paravesical space is opened by gentle blunt dissection with the use of divergent forces until the umbilical artery is identified and mobilized medially (Fig. 25.8). This is an avascular space, and bleeding should not occur during dissection of the paravesical space. Once the dissection is performed deeper into the paravesical space, the obturator nerve and vessels can be identified on the medial aspect of the dissection. With continuation of the dissection approximately 1 to 2 cm deeper, the levator ani muscle is reached. The limits in this avascular space are the obturator internus muscle laterally, the bladder medially, the pubis symphysis anteriorly, and the cardinal ligament posteriorly.

Traction of the IP ligament at the level where it crosses the iliac artery exposes the artery, and the ureter is identified approximately 1 to 2 cm posterior to this plane. The pararectal space is then developed by placing medial traction on the ureter while dissecting between it and the internal iliac artery (Fig. 25.9).

At the point where the uterine artery emerges, the dissection is performed more deeply (1–2 cm), and the hypogastric nerve branches can be observed on the medial aspect (Fig. 25.10) of the dissection and the deep uterine vein crossing anteriorly. Avoiding any bleeding during this step is essential to allow proper visualization of the nerve. During the type B radical hysterectomy it is not necessary to perform extensive dissection of the hypogastric nerve. However, isolation and separation of the hypogastric nerve can be performed very similarly to the open approach for nerve-sparing radical hysterectomy, as described by Shingo Fujii. Detaching the hypogastric nerve branches from the posterior leaf of the broad ligament (Fig. 25.11) will allow division of the pararectal space laterally (Latzko space) and medially (Okabayashi space). The pararectal space limits are the internal iliac artery and levator ani laterally, the rectum medially, the sacrum posteriorly, and the paracervix anteriorly.

Pelvic Lymphadenectomy

Currently, we perform a sentinel lymph node dissection followed by a complete pelvic lymphadenectomy for cervical cancer. However, this approach may change soon because of the recent evidence in favor of a change to sentinel lymph node biopsy only. We prefer to perform these procedures before the radical hysterectomy because the uterine manipulation helps to expose the paravesical and pararectal spaces and the lymphatic tissue. Also, in the event of grossly positive nodes or nodes suspicious for metastatic disease, one can then send these nodes for frozen section evaluation; if confirmed to be positive, then one may abort the radical hysterectomy. Some surgeons prefer to
perform the hysterectomy first. Usually, those surgeons do not use manipulation, and hysterectomy provides better exposure of the pelvic side wall for the lymphadenectomy.

**Posterior Leaf of the Broad Ligament, Uterosacral Ligament, and Rectovaginal Space Dissection**

The posterior leaf of the broad ligament has the ureter attached to it, and these should be gently separated from each other before the peritoneum is cut. Once the ureter is free from its attachment to the peritoneum, the surgeon enters the medial pararectal space previously dissected during hypogastric nerve identification. Then the surgeon can cut the uterosacral ligament at the level of the paracervix, which will be transected where it crosses the ureter, approximately 2 cm from the point where the uterosacral ligament meets the cervix (Fig. 25.12). Another option is to transect the peritoneum from the ureter toward the rectovaginal septum bilaterally, performing a U-shaped incision. This incision will facilitate the rectovaginal space dissection and exposure of the uterosacral ligaments and ureters (Fig. 25.13).

**Mobilization of the Bladder**

The peritoneal reflection of the vesicocervical fold is incised while the first assistant grasps the bladder wall with atraumatic forceps and the second assistant pushes the uterus cranially with the uterine manipulator. The vesicovaginal space is gently dissected approximately 3 cm down to the cranial level of the bladder trigone (Fig. 25.14). A colpotomy delineator, usually present on the manipulator, can be used to help the dissection or to determine the length of vagina to be resected. Patients with previous cesarean deliveries are usually at risk for bladder injury at this point, and extra caution is advised. The vesicouterine pillars become apparent and are resected halfway from the cervix to the bladder.

**Ureteral Tunnel Dissection**

On the left side, to expose the ureter for dissection of the ureteral or parametrial tunnel, the surgeon holds the uterine artery lateral to the ureter and pushes the artery anterolaterally. The first assistant holds the uterosacral ligament and pushes it medially (Fig. 25.15). This exposure will allow the surgeon to detach the ureter by using a combination of gentle aspirator pushing and dissection with a Kelly clamp. On the right side, the surgeon holds the uterosacral ligament and the assistant holds the uterine artery, repeating the process. A small branch from the uterine artery to the vascular plexus that runs along the ureter is constant. This branch should be gently coagulated.
and cut, leading to immediate exposure of the ureteral tunnel roof (Fig. 25.16). This step will help during ureteral mobilization. Placement of ureteral stents before the laparoscopic radical hysterectomy is no longer performed by most surgeons because it does not minimize injury to the ureters.

**Uterine Pedicle Section and Paracervical Tissue Dissection**

During this step, the uterus has to be lateralized as much as possible while being pushed cranially. During type B radical hysterectomy, the uterine artery can be coagulated and cut at the level where it crosses the ureter. It also can be cut at its origin and then rolled over the ureter; thus the lateral parametrial tissue is brought over the ureter and toward the uterus. The second option is preferred because it also removes additional lymph nodes in this area. However, cutting the artery at the level of the ureter prevents excessive ureteral dissection and preserves collateral vascularization, thus helping to reduce the risk of fistula or stenosis.

Use of a vessel-sealing device helps to accomplish paracervical tissue dissection because bleeding may occur from the large vascular network in this area. As the dissection progresses, one will identify the area previously dissected from the tunnel, and the ureter is unroofed. The lateral aspect of the vesicouterine ligament is cut along the level of the ureter, and the bladder is mobilized distally, connecting with the previous dissection of the vesicovaginal space. It is important to remember that use of monopolar energy is discouraged during this step.

The medial attachments of the ureter to the paracervical tissue are dissected, and gentle lateral mobilization of the ureter is performed (see Fig. 25.16). The paracervical dissection is extended distally for another 1 to 2 cm under direct visualization of the hypogastric nerve. The dissection should then be directed toward the vaginal wall. Careful hemostasis is advised at this point because bleeding may occur owing to the vaginal venous plexus.

**Colpotomy and Uterine Extraction**

With the cup of the uterine manipulator, the vaginal junction to the cervix can be palpated, and monopolar cutting energy is used to make an incision 2 cm inferior to the upper edge of the manipulator cup. Air leakage is avoided by using the manipulator silicone ring or balloon. It is important to avoid air leakage to prevent unintentional lesions of the ureters, bladder, and rectum. The first assistant can aspirate the smoke generated by the monopolar energy device to help maintain visibility. If a large amount of smoke accumulates and vision is significantly impaired, then it is better to stop, evacuate all gas, and then fill the cavity with gas again.

The uterus is extracted vaginally if it is not larger than 350 g. In the case of a larger uterus, it is possible to insert it into an extraction bag, exteriorize the proximal end of the bag through the vagina, pull the cervix with a grasper, section the uterus 1 or 2 cm proximal to the cervix, and extract the cervix intact. With this technique, the cervix keeps its integrity for pathologic examination, and the rest of the uterus can be morcellated vaginally without the risk of abdominal contamination by tumor. The vaginal cuff is closed in a similar fashion to the technique described earlier (Fig. 25.17).

**Ovarian Transposition (Oophoropexy)**

Ovarian transposition is performed during the radical hysterectomy to prevent early ovarian failure in premenopausal women who may undergo pelvic radiation therapy. The patient’s age, ovarian function, personal preferences (e.g., willingness to take hormone therapy for premature menopause), and tumor characteristics affect this decision. This procedure may be offered to premenopausal women or to those younger than 45 years.

One review found that ovarian function was preserved in approximately 90% of the patients subjected to ovarian transposition alone (i.e., without radiotherapy). According to other studies, in patients who received radiotherapy after ovarian transposition, the rate of preserved ovarian function varied from approximately 60% to 90%. Because even when the ovaries are transposed, there may still be ovarian function compromise, and patients should be aware that this technique is not always successful.

The ovaries are mobilized from the pelvis to a level 4 or 5 cm proximal to the point at which the IP ligament crosses the iliac vessels. The ovaries are placed at the level of the inferior pole of the kidney and sutured or clipped to avoid migration back into the pelvis. It is important to avoid torsion or kinking of the ovarian vessels when the ovaries are transposed. Also, one should note that permanent suture should always be used. An extraperitoneal tunnel can be created to prevent internal herniation of the cecum posterior to the ovarian pedicle, and this also helps the surgeon place the ovaries in a more anatomic position.
Laparoscopic Type C Radical Hysterectomy (Video 25.4)

Type C radical hysterectomy corresponds to variants of classic radical hysterectomy, also called distal radical hysterectomy in the Querleu-Morrow classification or Piver type III procedure. This procedure is indicated in the setting of cervical tumors larger than 2 cm and is associated with higher risk of urinary and rectal complications. Indications and preoperative evaluation are discussed in detail in Chapter 7.

The operation is performed similarly to the type B radical hysterectomy. However, the lateral paracervix is resected, including the deep uterine vein. The identification of the hypogastric nerve branches is essential, and the pararectal medial (Okabayashi space) and pararectal lateral (Latzko space) dissection cannot be neglected (see Fig. 25.10) in type C1 radical hysterectomy, also known as nerve-sparing radical hysterectomy.

Once the ureter is free from its peritoneal attachments, a U-shaped incision of the peritoneum is performed from one ureter to the other across the cul-de-sac. The rectovaginal space is dissected, and the uterosacral ligament is fully exposed (see Fig. 25.11). Mobilization of the bladder and ureteral tunnel exposure are the same as described earlier for type B radical hysterectomy.

Uterine Pedicle Section and Paracervical Tissue Dissection

During this step, the uterus has to be lateralized as much as possible while being pushed cranially. During type C radical hysterectomy, transection of the paracervix occurs at this junction with the internal iliac vascular system, so the uterine artery is coagulated and cut at its origin on the internal iliac artery (see Figs. 25.16 and Fig. 25.18). In the posterior aspect of the resection, the hypogastric nerve (see Fig. 25.11) is identified in the pararectal space and systematically preserved by transection of only the uterine branches of the pelvic plexus. The deep uterine vein is transected, but the neural component of the paracervix caudal to the vein is preserved.

The uterine vessels are brought over the ureter, along the paracervical tissue surrounding it. As the dissection progresses, the surgeon reaches the area previously dissected from the tunnel, and the ureter is unroofed (see Fig. 25.15). The lateral aspect of the vesicouterine ligament is cut along the bladder wall, and the bladder is mobilized distally, connecting with the previous dissection of the vesicovaginal space. The posterior part of the paracervix is also resected, and the ureter is mobilized completely. The deep uterine vein is the caudal limit of the lateral paracervical resection, located approximately 1 to 2 cm below the uterine artery and vein. Deeper to this vein, the branches of the deep hypogastric nerve plexus run to the bladder, and their transection will result in urinary retention (Fig. 25.19). The laparoscopic surgeon must avoid aggressive distal dissection, which can result in excessive vaginal resection and impaired sexual activity. Fig. 25.20 shows the final aspect after nerve-sparing radical hysterectomy.

Surgery Completion Survey

At the completion of the operation, the abdominal and pelvic cavities must be evaluated to ensure that there is no bleeding. The routine use of cystoscopy after robotic gynecologic oncology surgery does not appear to affect detection of intraoperative lower urinary tract injury during gynecologic surgery. However, cystoscopy is relatively simple to perform and can be used in the case of suspected bladder or ureteral injury. In patients with suspected ureteric ischemia, a 6F double-J stent should be inserted by means of cystoscopy. The use of drains does not reduce the postoperative risk of lymphocyst formation and may even have an adverse effect, with more late symptomatic lymphocysts (3.4% vs. 0.9%).

Postoperative Care After Laparoscopic Radical Hysterectomy

Patients can resume a regular diet immediately after the operation, and ambulation is encouraged as soon as possible. Most patients are discharged on postoperative day 1. The use of antithrombotic therapy and prevention of deep venous thrombosis...
(DVT) varies among surgeons. Given that all women undergoing laparoscopic or robotic radical hysterectomy score at least a 4 with the Caprini risk assessment model (2 points for laparoscopic operation longer than 45 minutes and 2 points for malignancy), the American College of Chest Physicians (ACCP) guidelines suggest low-molecular-weight heparin (LMWH), low-dose unfractionated heparin (LDUH), or mechanical prophylaxis, preferably with intermittent pneumatic compression (IPC), over no prophylaxis. If the patient has one more risk factor (e.g., age above 40 years, BMI >25 kg/m², central venous access) and a score of 5 or higher, the patient is at high risk for VTE, and the ACCP recommends extended-duration pharmacologic prophylaxis (4 weeks) with LMWH over limited-duration prophylaxis and mechanical prophylaxis with elastic stockings or IPC in addition to pharmacologic prophylaxis. Some authors have questioned the extended use of LMWH. Despite the reduction in rates of venous thromboembolism (VTE) within 30 days of operation with extended use of LMWH, this effect was not sustained within 90 days of operation. Corr and colleagues examined the addition of preoperative subcutaneous unfractionated heparin and extended-duration pharmacologic prophylaxis of up to 14 days with LMWH to their institution’s current practice. They found a decreased incidence (6.67% to 2.7%) of 90-day VTE. Regarding the laparoscopic approach, Bouchard-Fortier and colleagues reported the findings from a series of 352 patients who underwent minimally invasive surgery for gynecologic cancer without DVT prophylaxis. At least a total laparoscopic hysterectomy (simple or radical) or pelvic lymph node dissection was performed in 95% of these patients. The rate of VTE in the untreated patients was 0.57% (one pulmonary embolism and one DVT), which calls into question the routine use of VTE prophylaxis in this population. Unfortunately, current guidelines and risk assessment scores do not differentiate between minimally invasive surgery and open surgery. A strategy of IPC prophylaxis is generally associated with little risk and should therefore be used for all patients. In our institution, we favor the use of preoperative prophylaxis and 14 days use of LMWH after discharge.

There is controversy regarding when is the best time to remove the urinary catheter after laparoscopic radical hysterectomy. Some groups advocate retrieval of the catheter on the first postoperative day or even on the day of operation. In our institution, we remove the urinary catheter on the first postoperative day in type B radical hysterectomy and then check the residual urine. If the patient has more than 100 mL of residual urine, then we recommend self-catheterization every 4 hours, until it becomes less than 100 mL. In type C1 radical hysterectomy, we prefer to send the patient home with the catheter and check for residual urine on postoperative day 3.

**Laparoscopic Radical Trachelectomy**

Laparoscopic radical trachelectomy is currently considered a very viable option for patients with early-stage cervical cancer (IA2–IB1) who are interested in future fertility (see Chapter 5 for details). The first laparoscopic radical trachelectomy was reported in 2003 by Lee and colleagues. Considering all possible approaches for this procedure, approximately 6% of all operations are performed with a laparoscopic (non–robotic-assisted) approach. Park and colleagues described a relapse rate of 6% and a death rate of 1.7%, with a pregnancy rate of 23.9%. Every pregnancy after radical trachelectomy should be considered a high-risk pregnancy and treated as such (Box 25.2). The minimally invasive approach, including the robotic-assisted approach, is associated with less blood loss and shorter length of stay but is still not proven to be superior to the open approach with regard to the pregnancy rate.

**BOX 25.2 Recommendations for Management of Pregnant Patients After Radical Vaginal Trachelectomy (RVT)**

- Every pregnancy after RVT should be considered a high-risk pregnancy and should be treated as such.
- An examination should be performed each week, including:
  - Measurement of remaining cervix (sterile vaginal sonography)
  - Swabs and film (bacterial infections, fungal infections)
  - Speculum (exclude funneling)
- Improve vaginal flora if pathologic bacterial flora are present.
  - Supplementation with *Lactobacillus acidophilus* cultures
  - Supplementation with hexetidine, if appropriate
  - Oral antibiotics, if appropriate
- Vaginal pH measurements are performed by patient twice a week from 14th week of gestation onward.
- No digital examination is performed.
- If the remaining cervix is <1 cm or after previous premature delivery or recurrent miscarriages: abdominal cerclage (before pregnancy, with a laparoscopy; if patient is already pregnant, with laparotomy [low transverse incision]) and complete closure of cervical os (preferably with CO₂ laser techniques) are performed.
- The patient is admitted to the hospital if premature contractions, cervical incompetence, bleeding, or difficult social circumstances are present.
- Time off work is required from the beginning of the 12th week of gestation.
- Physical strain is avoided (no sports, no lifting of objects >2 kg, but patient is not placed on bed rest) until the 20th week of gestation. Between the 20th and the 28th weeks of gestation, this regimen should be intensified, with the patient placed on mainly bed rest (walking to the toilet is permissible).
- Primary elective cesarean section is performed from the 37th week of gestation onward.
- Delivery is performed in a perinatology unit.
- No elective dental work is performed during pregnancy.
- The patient should engage in no vaginal sexual intercourse between the 14th and 34th weeks of gestation.
- Simultaneous psycho-oncological counseling may be undertaken, if necessary and wanted by the patient.
- Use oral progesterone if twins or recurrent miscarriage—progesterone 200 mg three times a day from diagnosis of pregnancy until the 16th week of gestation, then slow reduction over 2 to 3 weeks. Avoid vaginal route.
- Induction of lung maturing with betamethasone is performed between 24 and 34 weeks of gestation if delivery is likely.
Box 25.2 Recommendations for Management of Pregnant Patients After Radical Vaginal Trachelectomy (RVT) — Authorized by Prof. Christhardt Köhler — cont’d

- Prophylactic antibiotics are given only if premature rupture of the amniotic sac occurs or if proven infection is present.
- Chorionic villus sampling (CVS) and amniocentesis are performed for the same indications as for patients who did not undergo RVT.

Recommendations developed from Professor Christhardt Köhler team experience from Vaginal Radical Trachelectomy. Courtesy Professor Christhardt Köhler.

Technique of Laparoscopic Radical Trachelectomy

After the patient has been placed in a steep Trendelenburg position, the blue dye, radioactive tracer, or indocyanine green (ICG) is injected into the cervix for the sentinel lymph node identification. Once the abdominal inspection is completed, the operation starts with dissection of the paravesical space. It is important to keep in mind that care must be taken to avoid grasping the tubes, the IP ligament, or the utero-ovarian ligament, because this could jeopardize the vascular supply to the uterus or damage the tubes, potentially contributing to worse success in future attempts to conceive. In general, all uterine mobilization is possible by grasping the round ligament. However, the use of a uterine manipulator is also permitted.

The peritoneum along the lateral aspect of the external iliac artery at the point at which the round ligament crosses the artery is incised. This peritoneal opening is extended proximally and laterally along the artery and the IP ligament. Alternatively, some surgeons cut the round ligament for the exposure of the retroperitoneum and then suture it at the end of the procedure. The dissection of the pelvic spaces is very similar to that described earlier for radical hysterectomy. The paravesical space is dissected up to the levator ani, and the obturator nerve is identified. The pararectal fossa is also dissected, and the hypogastric nerve is identified.

Vesicovaginal Space Dissection, Rectovaginal Space Dissection, and Uterosacral Resection

Similarly, these steps are performed exactly as in the laparoscopic radical hysterectomy. The uterosacral ligament can be sealed and cut at the same level where the paracervix is transected. If the uterine artery will be ligated at the level of the ureter, the uterosacral ligament is transected at the same level, approximately 2 to 3 cm from its insertion to the cervix (Fig. 25.21). If the uterine artery is ligated at its origin from the internal iliac artery, the uterosacral ligament is transected at the level of the rectum, as in type C1 radical hysterectomy.

Uterine Artery Ligation and Paracervical Resection

In performing a radical trachelectomy, the uterine artery may be preserved or cut at its origin. When preserving the uterine artery, the surgeon must be aware that there may be increased bleeding during the dissection and that surgical time may be longer. It has been shown that preservation may not guarantee that there will not be vascular compromise.

One study reported that 43.6% of patients have unilateral occlusion of the uterine arteries after abdominal radical trachelectomy with uterine artery preservation, and the same number (43.6%) have bilateral occlusion. Uterine necrosis after radical trachelectomy is a rare occurrence. In our institutions, as in many others in which radical trachelectomy is performed, it is not uncommon to routinely coagulate the uterine vessels bilaterally.

Once the uterine artery has been transected, gentle upward traction allows resection of the paracervical tissue surrounding it. Before the ureter is unroofed, it is gently freed from its tunnel with Kelly dissectors. Once the ureter is partially free, upward traction of the ureteral vessels is applied, and this tissue is dissected. The ureter is unroofed while the paracervical tissue is brought up over it (Fig. 25.22). The paracervical dissection continues up to the point at which the ureter enters the bladder. The ureter is mobilized laterally, and its medial attachments are transected. At this point, it is very important to avoid excessive coagulation in order to prevent ureteral fistula or stenosis.

In patients with a tumor smaller than 2 cm, the deeper portion of the paracervix is coagulated and cut at the level of the ureter, as in type B radical hysterectomy. Because the “nerve plane” is posterior to the ureter, it is important to avoid transection of the fibers that innervate the bladder, as in type C1 radical hysterectomy. Around 1 cm posterior to the ureter, the deep uterine vein is coagulated and cut while the ureter is pushed...
laterally, as in type B radical hysterectomy (see Fig. 25.16). The deep uterine vein also marks the point at which the surgeon should proceed with medial dissection toward the vagina. With dissection toward the vagina, the vaginal venous plexus is present, and careful hemostasis is advised.

**Colpotomy**

The vagina is incised by using monopolar energy 2 cm distal to the cervix. A vaginal probe can help push the uterus cranially while the assistant lateralizes the ureters and the surgeon proceeds with the colpotomy. The uterus is then gently pulled through the vagina.

**Cervical Transection and Margin Evaluation**

The patient is in a lithotomy position, and the surgeon is seated for the perineal approach. The cervix is gently pulled to prevent damage to the vascular supply originating from the IP ligaments to the uterus (Fig. 25.23). The surgeon palpates the cervix to make sure there is enough free margin. Clamps are applied to the uterine vessels at the level of the isthmus and may be sutured now or after cervical section. The cervix is amputated approximately 1 cm distal to the internal ostium of the cervical canal (Fig. 25.24). The transection can be performed with a cold scalpel or with the monopolar energy device in cut mode. The specimen is sent for frozen section analysis to ensure free margins. The objective is a 10-mm free margin for adenocarcinoma and 5 mm for squamous cell carcinoma. Some surgeons advocate a small shaving of the preserved cervix for a double margin check on final pathologic assessment. The uterus is then placed back into the abdominal cavity.

**Cervical Cerclage and Uterine Repositioning**

Gentle traction of the sutures used to control the uterine vessels facilitates cervical remnant exposure. We proceed with cervical cerclage by using nonabsorbable suture (0-Ethibond or 0-Prolene). Usually we recommend placement of the cerclage suture knots posteriorly to avoid extrusion into the bladder. Before proceeding with tightening of the cerclage suture, a No. 4 Hegar dilator is introduced into the canal to ensure that there is no stenosis of the canal. A Foley catheter or a Smit sleeve cannula (Nucletron, Columbia, Maryland) can be inserted into the canal and sutured to the cervix with 2-0 nylon, to be extracted 4 weeks after operation. See Chapter 5 for a more extensive discussion of this topic. Some surgeons do not place the cerclage during the procedure. Whether or not to place a cerclage at surgery depends on the surgeon’s experience and clinical practice.

Another potential option when performing amputation of the cervix is to perform all components of this step intraabdominally. This is done by turning over the uterus and transecting the cervix and parametria. The trachelectomy specimen is then removed vaginally and sent to the pathology department for frozen section evaluation. Once adequate margins have been confirmed, the uterus is sutured to the vaginal cuff laparoscopically or through the vagina with absorbable sutures. We believe that use of the vaginal route is easier and faster (Fig. 25.25).

**Laparoscopic Pelvic Lymphadenectomy (Video 25.6)**

Querleu and colleagues\(^3\) described the first series of laparoscopic pelvic lymphadenectomies in cervical cancer in 1991. It quickly became the paradigm for the use of laparoscopy in gynecologic tumors and has been extensively compared with its open counterpart; eventually it became the standard approach for this surgical procedure. Laparoscopic pelvic lymphadenectomy has been established as the standard approach for staging endometrial cancer.

**Technique**

The authors’ approach to pelvic lymphadenectomy is to have the second assistant retract the uterus to the contralateral side with the manipulator. This maneuver helps expose the paravesical
space and all the pelvic lymph nodes distal to the iliobifurcation. The lateral limit of the pelvic lymphadenectomy is the genitofemoral nerve, which is easily identified lateral to the external iliac artery (Fig. 25.26). In obese patients, the surgeon dissects the fatty tissue lateral to the external iliac artery to identify this structure. With a combination of blunt dissection, coagulation, and cutting along the medial border of the nerve, the lateral limit of the dissection is achieved. The femoral branch frequently runs over the external iliac artery, and the lymphatic tissue can be dissected from it. As the dissection extends distally, the circumflex iliac vein is observed and defines the distal limit of the lymphadenectomy. During laparoscopy, this vein is frequently collapsed, and it may become challenging to identify. The dissection continues medially, bypassing the external iliac artery and then the external iliac vein, which is located medially and inferior to the artery. Gentle dissection of the medial wall of the external iliac vein will present the pectineal line (Fig. 25.27). The lymphatic tissue medial to the vein is removed to the level of the pectineal line.

To achieve proximal dissection, the following steps are suggested. The first assistant retracts the IP ligament medially while the surgeon dissects the lymph nodes laterally to the common iliac artery. In some patients a small branch from the external iliac artery to the psoas muscle can be found and may cause bleeding if not properly coagulated. The lymph nodes are dissected from the pelvic side wall up to the obturator fossa. Small vessels connecting the pelvic side wall to the internal iliac vascular system are found on the obturator fossa and can be coagulated and cut.

**Lateral Identification of the Obturator Nerve and Dissection of the Lumbosacral Lymph Nodes**

As the surgeon dissects posterior to the common iliac artery, the common iliac vein is identified, and subsequently the obturator nerve. This runs lateral to the junction of the external and internal iliac veins (Fig. 25.28). Approximately 5 mm deeper, the lumbosacral trunk (anterior rami of the L4 and L5 nerve roots) emerges from the lumbosacral fossa.

**Detaching the Lymph Nodes from the Iliac Vessels**

After all lymph nodes have been detached from the lateral aspect of the common iliac artery and vein, the surgeon continues the dissection on the medial aspect of the common iliac artery. Using traction and countertraction maneuvers, the surgeon detaches the lymph nodes at the level of the common iliac artery bifurcation. Care must be taken at this point to avoid injury to the iliac vein, which runs posterior to the artery bifurcation.

**Lymphadenectomy of the Obturator Fossa**

The obturator nerve is dissected, and the pelvic lymphadenectomy concludes with the resection of the obturator fossa lymph nodes (Fig. 25.29). In this area, blunt dissection is very effective, but small vessels may bleed. If the obturator vessels are accidentally disrupted, the bleeding can be significant. Hence, we recommend gentle dissection and precise coagulation and cutting.
techniques. The lymph nodes are placed into a bag and can be extracted through the vagina or abdominal wall. Drains are not routinely used.

**Laparoscopic Transperitoneal Paraaortic Lymphadenectomy**

Querleu and LeBlanc described the first cases of laparoscopic infrarenal paraaortic lymphadenectomy in patients with carcinoma of the ovary or fallopian tube. This technique has been extensively studied in endometrial cancer and has consistently been shown to be as safe and effective as the laparotomic procedure. The patient is prepared in the standard fashion as previously mentioned (see Fig. 25.1). However, unlike the pelvic procedures, the surgeon is on the patient’s right side, the first assistant is between the patient’s legs, and the second assistant is on the left (Fig. 25.30). Some surgeons prefer to stay between the patient’s legs while the assistants are placed beside the patient. The ports are placed as previously mentioned in this chapter (see the section on trocar placement) for paraaortic lymphadenectomy; port placement is presented in Fig. 25.31. This setup is a mirror image of the pelvic procedures and allows the surgeon to work facing the retroperitoneal area to be dissected with a frontal view.

It is possible to perform the retroperitoneal lymphadenectomy without the suprapubic port, with the camera on the umbilical site; however, this requires greater expertise, and the distal part of the lymphadenectomy is performed almost upside down.

**Retroperitoneal Exposure**

Exposure of the retroperitoneum is very important when one is attempting to perform a paraaortic lymphadenectomy. Failure to attain adequate exposure is one of the most common reasons for surgeons not to perform a full lymphadenectomy to the renal vessels. When the steps as suggested here are applied, it is certainly feasible to achieve an adequate lymphadenectomy, even in obese patients.

The operation starts with the placement of the small bowel on the superior abdomen, particularly on the right side.

A small right lateralization of the surgical table can be helpful to keep the bowel on the right side. The retroperitoneum is opened over the right common iliac artery up to the duodenum. Dissection of the avascular plane between the retroperitoneum and the duodenum is then performed. It is crucial to maintain excellent hemostasis in this area to ensure excellent exposure of the anatomic landmarks. On the right side, the peritoneum is dissected up to the level of the ovarian vessels. On the left side it is dissected up to the level of the ligament of Treitz.

Stay sutures with straight needles or devices specifically designed for this purpose, such as the T’Lift (Vectec, Hauterive, France), are placed through the abdominal wall to suspend the edges of the peritoneum and expose the retroperitoneal area over the infrarenal aorta and vena cava. These sutures are inserted lateral to the trocars to avoid conflict with the instruments. The sutures are fixed with Kelly clamps (see Fig. 25.31) outside the abdominal wall, and traction of the sutures can be adjusted. The number of peritoneal suspension sutures varies from two in thin patients to six or even more in obese patients. Fig. 25.32 shows the retroperitoneal exposure after placement of the transabdominal sutures.
Paracaval Dissection and Ovarian Vessel Resection

The dissection should start at the level at which the right ureter crosses the right common iliac artery. The ureter is the lateral limit of the dissection, and the surgeon protects it with the right port instrument. The second assistant grasps the lymphatic tissue over the common iliac vein, and the surgeon dissects it from the vessels (Fig. 25.33). The use of vessel-sealing devices helps to achieve faster dissection with less blood loss. The dissection progresses until the right ovarian vein drains into the vena cava (Fig. 25.34). Approximately 1 to 2 cm above the insertion of the right ovarian vein into the vena cava, the renal vein is identified. An instrument placed through the umbilical port is used to retract the duodenum and facilitates this proximal part of the dissection. On the lateral and posterior aspect of the paracaval dissection, the psoas muscle is identified. As the lymph nodes are detached from the muscle, the right sympathetic chain is dissected, as well as the right lumbar veins. Once the lymphatic tissue lateral to the vena cava is dissected, the second assistant uses medial and anterior traction to expose the anterior wall of the cava. Small venous branches entering the cava are common, and some are known as “fellow’s veins.” They can cause significant bleeding and must be identified, sealed, and cut with caution.

Presacral and Intercavoaortic Dissection

The next step is the dissection of the presacral lymph nodes lying between the proximal common iliac arteries. Anterior to those nodes, the superior hypogastric plexus gives origin to the hypogastric nerves. If a nerve-sparing procedure is possible, these nerves are gently displaced during this step while the surgeon removes the nodes underneath. The confluence of the common iliac veins takes place at this level. The second assistant pulls the lymphatic tissue, while the surgeon proceeds with the dissection to the distal part of the aorta.

The next step is the resection of the intercavoaortic lymph nodes. This dissection should be performed very carefully because of the risk of the lumbar vessels bleeding (see Fig. 25.34). The surgeon retracts the vena cava laterally and the second assistant retracts the aorta, and the dissection extends up to the left renal vein (Fig. 25.35). Below the left renal vein, one can identify the right renal artery. All the intercavoaortic lymph nodes are resected at this point.

Paraaoortic Inframesenteric Dissection

The operation continues with the dissection of the left common iliac vessels. The superior hypogastric plexus is identified and can be preserved, with the second assistant pushing it laterally together with the left ureter. One should hold the lymphatic tissue lateral to the aorta with the left hand and use the operative port (right hand) to dissect the lateral wall of the aorta. As the dissection progresses, the psoas muscle is identified, as are the left lumbar arteries. On the anterior limit of the dissection, the inferior mesenteric artery crosses the paraaortic lymph nodes. During this step, excessive traction of this artery may cause avulsion and severe bleeding. Colon necrosis is uncommon but may occur in older patients. Large metastatic lymph nodes or recurrences lateral to the aorta at this level are difficult to access using this technique. These can be very challenging owing to the risk of rupture of the lumbar arteries and veins. Posterior to the aorta one can identify several lumbar vessels, the sympathetic trunk (Fig. 25.36), and the intervertebral discs.

Paraaoortic Supramesenteric Dissection

The dissection of the lymph nodes above the inferior mesenteric artery is more commonly performed in the setting of ovarian and endometrial cancer. The left ovarian vein can be dissected up to the insertion into the left renal vein. After complete identification of the left ovarian vein, the left ureter and renal pelvis can be identified posteriorly. The lymph nodes located between the inferior mesenteric artery and the renal vein are dissected carefully, and the surgeon must be watchful for the presence of the communication between the left renal vein and the azygos vein. Also, one must be careful to identify the left renal artery posterior to the left renal vein.
There are a number of large lymphatic ducts anterior to the left renal vein. We prefer to clip them to prevent lymphocysts. This completes the retroperitoneal lymph node dissection (Fig. 25.37). The specimen is placed in an extraction bag. There is no need for drain placement, and the peritoneum is left open, thus reducing the incidence of lymphocysts.

Laparoscopic Surgery for Ovarian Neoplasms

Adnexectomy for Suspected Ovarian Cysts (Video 25.8)

Laparoscopy is the gold standard in the management of benign ovarian tumors or malignant neoplasm of early stage. This approach is associated with reductions in fever, urinary tract infection, postoperative complications, postoperative pain, number of days in the hospital, and total cost. There is a need for drain placement, and the peritoneum is left open, thus reducing the incidence of lymphocysts.

Aorta

Left common iliac artery

Sympathetic chain

FIG. 25.36 Left sympathetic chain is dissected with a vessel-sealing device in the surgeon’s right hand. The right ureter is mobilized laterally by the second assistant.

Aorta

Lumbar artery

Sympathetic chain

FIG. 25.37 Final view of the non-nerve-sparing retroperitoneal lymphadenectomy.

Technique

After proper exploration of the abdomen and pelvis, one should collect any fluid in the abdominal or pelvic cavity and submit this for cytologic evaluation. If there is none, the surgeon irrigates the pelvis with saline solution and aspirates. This step should be done before any dissection. The broad ligament along the lateral aspect of the IP ligament is opened from the point at which the IP ligament crosses the iliac artery to the round ligament, while the assistant uses medial traction of the IP ligament to expose this area. The posterior leaf of the broad ligament is exposed just posterior to the IP ligament. The medial leaf of the peritoneum is opened, creating a “window” to help avoid ureteral injury.

Adnexectomy

The IP ligament is coagulated or sealed and cut. If the surgeon prefers not to make the window, the ureter must be checked before this step. Caution should be taken in patients with endometriosis, because the ureter may be closer or even attached to the IP ligament because of fibrosis. While the assistant pulls the IP, the second assistant manipulates the uterus anteriorly, and the surgeon coagulates the IP ligament. Next, the utero-ovarian ligament is sealed and cut, finishing the adnexectomy.

Cyst Extraction

To facilitate the extraction of the cyst, it should be evacuated, if possible. This can be done during the laparoscopy inside the bag with laparoscopic needles (Fig. 25.38). The use of scissors to start the cyst evacuation is not advised, because the tension in the cyst might spill liquid outside the bag. Once the cyst has already been partially evacuated, it can be cut and aspirated. This option is helpful with mucinous tumors because time to evacuate the cyst contents may be prolonged as a result of the cyst content being very viscous.

A good option for evacuation of the cyst is to exteriorize the bag through the trocar in the abdominal wall and to aspirate it under direct visualization. This step can also be done through the vagina if a hysterectomy has been performed. The umbilical port can be used as the extraction site if after cyst aspiration the bag can be easily extracted without enlarging the umbilical incision. If a larger incision is needed, a Pfannenstiel or a midline incision may be used. The Pfannenstiel incision should not be used if the surgeon plans to perform an open staging procedure in case of malignant tumors.

For very large cysts (>20 cm), we perform a small suprapubic incision to evacuate the cyst and extract it from the abdomen with a wound protector. We use the Applied Medical
In the reverse technique for infracolic omentectomy, the surgeon is cutting the omentum along the transverse colon from right to left (Fig. 25.39). This technique should be used in select patients, particularly when the adnexal cyst is larger than 8 cm. We recommend that the Endobag be at least 20% larger than the tumor. It is preferable to use Endobags that can be completely inserted into the cavity and are not attached to an instrument, because otherwise the surgeon loses one of the ports with the bag handle. Once the Endobag is inside the cavity, it must be opened before one tries to place it posteriorly to the ovary. While the assistant holds the edge of the bag at the 12-o’clock position, the surgeon’s left hand holds the bag at the 6 o’clock position. With the midline port, the surgeon opens the bag as much as possible. In the setting of a left ovarian cyst, the surgeon grasps the IP ligament while the first assistant, who is holding the bag at the 12-o’clock position, passes the bag edge under the ovary while the 6-o’clock grasper keeps the bag open. For the right ovary, the surgeon holds the bag at the 12-o’clock position, and the assistant at the 6-o’clock position, with the same maneuver, passes the bag under the ovary. For larger tumors, it is important to avoid rupture. Another maneuver is to hold the bag at the 2-o’clock and 10-o’clock positions by using the lateral ports and move them together, passing underneath the ovary.

During coagulation or sealing of the omental vessels, it is important to ensure that the vessel-sealing device is kept a safe distance from the colonic serosa to avoid thermal injury. As the surgeon progresses with the transection of the omental vessels, the assistant keeps tension on the omentum. The dissection continues to the splenic flexure. Usually, the omental attachment to the splenic flexure is easier to dissect from lateral to medial (left to right). At this point, the surgeon pulls the left border of the omentum medially, and the assistant pushes the descending colon (close to the splenic flexure) laterally while the surgeon detaches the omentum by using the sealing device with the right hand. The dissection is now from left to right, up to the moment the section areas meet and the omentectomy is completed.

**Omentectomy: Reverse Technique**

The omentectomy can be done by using the regular trocar positioning for pelvic procedures (see Fig. 25.3). This approach is called the “reverse technique.” While the camera is facing the pelvis, the assistant pulls the omentum toward the cul-de-sac, presenting the transverse colon from its anterior wall. In this technique the inframesenteric omentum is resected starting at the point where it is translucent and the transverse colon can be seen underneath it or just distal to the gastroepiploic vessels (Fig. 25.40). This technique should be used in select patients, because on the lateral aspects of the omentum, along the splenic and hepatic flexures of the colon, the resection is more difficult and may be incomplete. However, given that the omentectomy does not seem to offer any survival benefit for patients without advanced epithelial ovarian cancer (stage IIIA or less), this approach may be used more frequently in patients who do not have any sign of disease outside the ovaries.

**Key Points**

- Oncologic outcomes of laparoscopic and open approaches are equivalent in most gynecologic malignancies.
- Laparoscopic procedures for gynecologic cancers result in decreased length of hospitalization, reduced blood loss, faster recovery, diminished overall hospital charges, and less postoperative pain.
- Absolute contraindications to laparoscopy are limited to a small group of patients with the inability to tolerate the pneumoperitoneum or the Trendelenburg position.
- PSMs occur in approximately 1% of patients who have undergone laparoscopic procedures for a malignant indication.
• Patient and trocar placement is crucial and should never be underestimated in laparoscopy.
• Laparoscopic cavity inspection must be properly performed in all patients.
• Exposure of the pelvic spaces is crucial in order to perform complex pelvic surgical procedures.
• The minimally invasive approach should be considered the standard approach in endometrial cancer patients.
• Intraoperative tumor rupture is more frequent in patients undergoing laparoscopy compared with laparotomy.
• The use of endoscopic bags to protect the cavity is suggested during laparoscopic surgical procedures for ovarian cysts to avoid spillage.
• Diagnostic laparoscopy is the best option when determining ideal candidates for up-front cytoreductive surgery in advanced epithelial ovarian cancer.

References
Laparoscopic Approach to Gynecologic Malignancy

Surgery remains the mainstay of gynecologic cancer treatment, including radical hysterectomy, trachelectomy, and ovarian cancer cytoreduction. Historically, these procedures were performed through a large abdominal incision and were associated with prolonged hospitalization and significant morbidity. With advances in minimally invasive surgery (MIS), many of these operations are now being done as outpatient procedures, with less morbidity.

**Perioperative and Oncologic Outcomes in Minimally Invasive Surgery**

With the introduction of MIS for the management of gynecologic malignancies, there was initial concern regarding its perioperative and oncologic safety. Early randomized trials in early-stage endometrial cancer demonstrated significant short-term benefits to MIS when compared with laparotomy, including less blood loss, shorter hospital stay, decreased need for analgesics, and fewer complications. However, operative time was consistently longer for MIS. These results were confirmed in the Gynecologic Oncology Group (GOG) LAP2 trial, in which 2616 women with clinical stage I or IIA endometrial cancer were randomized to undergo comprehensive surgical staging via laparoscopy or laparotomy. In addition to confirming the feasibility and improved perioperative safety and quality of life conferred by MIS in endometrial cancer staging, the GOG LAP2 trial also confirmed its oncologic safety, demonstrating that identification of advanced disease and overall survival (OS) did not differ between the two groups. Laparoscopic management of endometrial cancer has now been accepted as an alternative to surgical staging via laparotomy.

The safety and feasibility of MIS in the management of early-stage cervical cancer have also been studied. Several groups have retrospectively compared perioperative outcomes between patients undergoing radical hysterectomy via laparoscopy versus laparotomy. Similar to the benefits seen with MIS in endometrial cancer, the laparoscopic cases resulted in less blood loss, fewer postoperative complications, and shorter hospital stays but longer operating times. Spirtos and colleagues demonstrated an acceptable recurrence rate of 10.3% with a mean follow-up of 66.8 months in 78 patients with stage IA2 and IB cervical cancer treated laparoscopically. However, this study did not include a comparison laparotomy group. In a retrospective cohort study comparing laparoscopy and laparotomy, Malzoni and colleagues did not find a significant difference in recurrence rates or disease-free survival (DFS). Preliminary data from the first randomized trial comparing MIS and laparotomy for radical hysterectomy in the management of early-stage cervical cancer were presented at the Society of Gynecologic Oncology (SGO) Annual Meeting in March 2018. These preliminary data indicate worse progression-free survival with MIS, contradicting prior retrospective reports. This is preliminary data from an international surgical trial; the full report and analysis are awaited prior to drawing definitive conclusions.

There are no randomized trials evaluating outcomes of laparoscopic radical trachelectomy for fertility-sparing treatment of early-stage cervical cancer. The findings of several retrospective series have indicated acceptable perioperative complication rates, recurrence rates, and obstetric outcomes. Ebisawa and colleagues described a series of 56 patients who underwent laparoscopic radical trachelectomy for stage IA2 and IB1 cervical carcinoma. They found an intraoperative complication rate of 3.57%, a recurrence rate of 1.8%, and a pregnancy rate of 52%. This is comparable to findings after both vaginal and abdominal radical trachelectomy, with reported recurrence rates of 4% and 3.8%, respectively, and pregnancy rates of 41.3% and 59.3%, respectively. Complication rates are higher for both abdominal (35.4%) and vaginal (19.5%) trachelectomy. Given comparable oncologic and obstetric outcomes and improved complication rates, laparoscopic radical trachelectomy has been accepted as an alternative to the vaginal and abdominal approaches.

Surgery plays an integral role in the treatment of ovarian malignancies, both in initial management and in the management of select recurrences. Frequently these procedures are performed through a large laparotomy incision and are associated with prolonged recovery. Use of MIS for ovarian cancer staging has been criticized owing to concerns about the adequacy of detection of occult metastatic disease, the risk of port-site metastases, and the risk of intraoperative tumor rupture. Several studies have compared outcomes in laparoscopy versus
laparotomy in the treatment of (apparent) early-stage ovarian cancer. Reports published as early as 2005 demonstrated shorter hospital stay, less blood loss, and no difference in number of lymph nodes (LN)s removed or size of omentum removed in laparoscopic staging. Five other comparative reports have confirmed these findings. In a series of 24 patients with apparent early-stage ovarian cancer treated laparoscopically and 53 patients treated with laparotomy, Koo and colleagues demonstrated that there was no difference in recurrence rates or DFS between the two groups, confirming the oncologic safety of a minimally invasive approach.

Fewer data exist regarding the laparoscopic primary debulking of apparent advanced-stage ovarian cancer; however, the available data suggest that, in carefully selected patients, it is safe and feasible. Nezhat and colleagues reported a retrospective analysis of 32 patients who underwent laparoscopic cytoreduction, compared with 11 patients who were initially evaluated laparoscopically but in whom the procedure was converted to laparotomy for debulking. They found an optimal debulking rate of 88.2% in the laparoscopic group and 72.7% in the laparotomy group, with no difference in time to recurrence between the two groups. Patients undergoing interval debulking were included. Fanning and colleagues described their experience in 25 patients with apparent advanced-stage ovarian cancer who underwent laparoscopic primary debulking. Twenty-three patients (92%) successfully underwent cytoreduction laparoscopically (defined as residual disease < 2 cm). This cohort had a median OS and median progression-free survival (PFS) of 3.5 years.

Secondary and tertiary cytoreduction of recurrent ovarian cancer is beneficial in select patients. Laparoscopic resection of recurrent ovarian cancer has been described in this setting and is feasible in carefully selected patients. In the largest series, described by Gallotta and colleagues, 27 patients underwent laparoscopic secondary cytoreduction. Optimal cytoreduction was achieved in 96.2%. There were no intraoperative complications, and only one patient had a postoperative complication. The median DFS was 14 months.

Nezhat and colleagues described their experience with 19 patients undergoing laparoscopic secondary cytoreduction and 4 patients undergoing laparoscopic tertiary cytoreduction. Optimal cytoreduction was achieved in 78.9% in the secondary debulking group and 100% in the tertiary debulking group. Fourteen of the 19 patients undergoing secondary cytoreduction achieved a second disease-free interval of longer than 6 months. Laparoscopic secondary and tertiary cytoreduction procedures appear feasible in carefully selected patients.

The risk of port-site metastases has been touted as one of the reasons to avoid MIS in gynecologic cancer; however, the reported rate is low. A meta-analysis of 11 studies evaluating laparoscopic management of apparent early-stage ovarian cancer showed only one instance of port-site metastasis. The rates reported in the literature range from 0.97% to 2.3%. In the largest series to date, Zivanovic and colleagues retrospectively evaluated 1694 patients with malignant intraabdominal conditions who underwent laparoscopic procedures. Port-site metastases occurred in 20 patients (1.18%). Factors associated with an increased risk of port-site metastases include recurrent ovarian cancer with large-volume ascites, or advanced disease with carcinomatosis. It appears that careful patient selection is likely to reduce the risk of port-site metastases.

Implementation and Expansion of Robotic Surgery in Gynecologic Oncology

The first robotic surgery platform was introduced for civilian use in the 1980s as another means of performing laparoscopy. The robotic surgery platform remains a means of performing laparoscopy. It should be emphasized that robotic surgery is a tool to aid the surgeon in performing a minimally invasive procedure. Robotic surgery devices were initially developed for the military, enabling surgeons to operate on wounded soldiers from a remote and safe location. The first robotic platforms to enter the civilian operating room were AESOP (Computer Motion, Goleta, California) and ZEUS (Computer Motion). AESOP was a voice-activated robotic arm used to control the laparoscope during a laparoscopic procedure. ZEUS, the model that followed AESOP, is the predecessor to the robotic platforms in use today. It included three robotic arms: one to hold the laparoscope and two operating arms that were controlled from a remote console.

The only U.S. Food and Drug Administration (FDA)-approved robotic surgery platform is the da Vinci Surgical System (Intuitive Surgical, Sunnyvale, California). This system includes three components: the vision cart (which contains the endoscope and cameras), the patient-side cart (which houses the robotic arms), and the surgeon console (where the surgeon sits to control the robotic arms). Intuitive Surgical released its first platform, the da Vinci Standard, in 1999, and in 2000 it was approved by the FDA for general laparoscopic surgery. This robotic platform consisted of four robotic arms with EndoWrist instruments (also known as “wristed” instruments, which have the capability to move in several different planes and mimic the motions of the human hand and wrist) and a camera providing three-dimensional vision. Intuitive Surgical released its next model, the da Vinci S, in 2008; this included three-dimensional high-definition vision, motion scaling and tremor reduction, and telestration via a touchscreen monitor on the vision cart (which allowed improved proctoring). The da Vinci Si was released in 2009. The main advantage of this model was the addition of a dual console, which enabled two surgeons to operate either simultaneously or in tandem. This improved the safety and ease of training new robotic surgeons. The most recent model released is the da Vinci Xi. The advantage of the Xi system is the capability of the robotic arms to rotate 180 degrees, allowing multiquadrant access without having to move the patient. The camera has also been reengineered and is smaller, allowing it to be placed in any of the robotic trocars and potentially to be moved during the procedure. These advances provide surgeons with more freedom, enhancing their ability to complete complex surgical procedures with a minimally invasive approach (Intuitive Surgical, 2016. Available at www.intuitivesurgical.com).

Advantages and Disadvantages of Robotic Surgery

Several benefits of the robotic system versus conventional laparoscopy have been cited. These include wristed instruments, reduction of surgeon hand tremors, improved visualization, and increased independence of the operating surgeon (i.e., less reliance on assistants). Since the FDA approved the use of the robot for gynecologic procedures in 2005, these advantages have led to a marked increase in the use of this technology.
by gynecologic oncology surgeons. A survey of SGO members demonstrated an increase in the use of robotics, from 27% in 2007 to 97% in 2012. The primary reasons cited by surgeons who used the robotic platform for more than 50% of their cases were improved dexterity, better visualization, and ergonomic comfort. In other surveys, respondents reported that the greatest advantages of the robotic platform were ease of use and their patients’ improved quality of life.

Several disadvantages have been cited as well. These include significantly increased cost, limited access, lack of haptic feedback, bulky equipment, and the need for additional staff and training. In the same survey of SGO members conducted in 2012, respondents who did not use the robotic platform described their main reasons for not using it as follows: the ability to perform all procedures via conventional laparoscopy, increased cost associated with the robot, lack of availability of a robotic system in their institution, a belief that use of the robotic platform limited fellow and resident education, and lack of support for oncologic safety in the current literature. Data regarding use of the robotic platform for specific procedures is presented in the following sections.

Despite the fact that laparoscopic instrumentation has been available for over 40 years, the rates of use of laparoscopy for gynecologic oncology patients remain low. This is because of the known limitations of standard laparoscopic instrumentation. An analysis of the Surveillance, Epidemiology, and End Results (SEER) Program Medicare database noted that less than 10% of all patients with endometrial cancer underwent a laparoscopic operation in 2005. The use of MIS has increased since that time, in great part as a result of the availability of robotic platforms. However, an analysis of the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database showed that, as of 2010, it was still less than 50%.

**Preoperative Evaluation**

The preoperative evaluations required for laparoscopic surgical procedures are the same as those for robotic procedures. Because robotic surgery is a minimally invasive tool, a patient who is ineligible for a laparoscopic procedure is also ineligible for a robotic procedure. Patient safety should be at the forefront of operative planning. If a surgeon does not have robotic experience or does not feel comfortable performing a specific procedure robotically, it should not be attempted.

**Perioperative Management—Enhanced Recovery Pathways**

There has been increasing interest in optimizing perioperative outcomes through the implementation of enhanced recovery pathways (ERPs) that decrease opioid narcotic use and hospital length of stay. These programs were implemented after several studies showed that some of the standard perioperative practices in use were not necessary, and some were even potentially harmful. The combination of the benefits of an ERP with the benefits of MIS enables patients undergoing uncomplicated procedures to go home on the same day.

Cornerstones of ERPs center on patient education, preservation of gastrointestinal function, minimization of organ dysfunction, active pain control, and promotion of patient autonomy. These are achieved specifically by reduction of preoperative fasting, omission of preoperative mechanical bowel preparation, maintenance of perioperative normovolemia, avoidance of or early removal of urinary catheters, avoidance of drains, use of multimodal analgesia with decreased narcotic use, preoperative analgesic use, early ambulation, and early postoperative oral intake.

There is good evidence that mechanical bowel preparations do not decrease postoperative complications, provide little improvement in intraoperative visualization, and cause a great deal of patient discomfort. A Cochrane review demonstrated no difference in anastomotic leaks or wound infections in patients undergoing elective colorectal surgery who had received a mechanical bowel preparation preoperatively, compared with those who had not. Won and colleagues evaluated mechanical bowel preparations before laparoscopic gynecologic procedures in a randomized single-blind trial. Their data demonstrate that surgeon visualization intraoperatively is minimally improved with bowel preparation, and patient discomfort is markedly worsened. Even in the setting of a planned bowel resection, there is no indication for administration of a mechanical bowel preparation.

Although the majority of the data surrounding ERPs are from patients undergoing extensive abdominal procedures via laparotomy, the addition of an ERP to minimally invasive procedures has demonstrated benefit. Lovely and colleagues compared an ERP and a baseline accelerated discharge program (the standard at their institution) in patients undergoing minimally invasive colorectal surgery. The main differences between the two pathways were the addition of preoperative nonopioid analgesics, decreased intraoperative and postoperative intravenous fluid administration, and early oral intake in the ERP. Length of stay, pain management, and return of gastrointestinal function were all improved in patients on the ERP.

A randomized trial also demonstrated that the addition of an ERP to MIS was beneficial. The LAFA study (Laparoscopy and/or Fast Track Multimodal Management Versus Standard Care) evaluated length of hospital stay for patients undergoing elective colorectal cancer resections via an open or laparoscopic technique, treated according to an ERP or with standard postoperative care; this resulted in four study groups. The median length of hospital stay was significantly shorter for the group undergoing a laparoscopic resection and treated according to an ERP, compared with the other three groups. Laparoscopy resulted in lower morbidity compared with laparotomy. There were no differences in readmission rates among the groups. These data confirm that the addition of an ERP to MIS is safe and beneficial to patient recovery.

**Surgical Techniques—Pelvic Procedures**

**Indications**

Pelvic procedures, including simple and radical hysterectomies, radical tracheectomies, and pelvic and paraaortic lymphadenectomies, are the mainstay of endometrial and cervical cancer management. Emerging data support the use of the robotic platform in the management of these diseases.
Although no randomized trials have been completed, a number of nonrandomized studies have found that robotic hysterectomy is safe and feasible in the management of endometrial cancer. Leitao and colleagues demonstrated that there was no difference between conventional laparoscopy and robotic-assisted laparoscopy with respect to extent of the procedure, total nodal counts ($P = .05$), and overall complications ($P = .1$). Length of stay was shorter for the robotic cases ($P < .001$). Operative times were longer with robotic surgery ($P < .001$), but this was mostly because of the associated learning curve (i.e., surgeons who had performed fewer than 40 robotic cases). After the learning curve was surmounted, operative times were similar ($P = .9$). Boggess and colleagues compared robotic-assisted laparoscopy, conventional laparoscopy, and laparotomy in endometrial cancer staging and found that the robotic cohort had a higher LN yield ($P < .0001$), shorter hospital stay ($P < .0001$), and lower estimated blood loss ($P < .0001$). Operative times were longest in the conventional laparoscopy group (mean, 213.4 minutes; $P < .0001$). Conversion rates were similar between the conventional laparoscopy and robotic-assisted groups ($P = .7$). The complication rate was highest in the laparotomy group (29.7%, vs. 13.6% in the conventional laparoscopy group and 5.8% in the robotic group; $P < .0001$). Several other series have shown similar results, indicating that robotic-assisted endometrial cancer staging is safe and feasible. Oncologic outcomes in robotic-assisted staging have been shown to be similar to those of conventional laparoscopy.

Radical hysterectomy for the management of cervical cancer has also been shown to be feasible with use of the robotic platform. Robot-assisted radical trachelectomy has increased in popularity. A survey of SGO members showed an increase in the percentage of those who believed that robotic surgery was appropriate for radical hysterecomies (from 60.2% in 2007 to 89.1% in 2012). Soliman and colleagues described a series of 95 consecutive patients treated with radical hysterectomy and pelvic LN dissection via a robotic-assisted conventional laparoscopic or open approach. Estimated blood loss ($P < .0001$) and infectious complications ($P < .01$) were significantly lower in the robotic-assisted and conventional laparoscopy versus laparotomy groups. Length of stay was shorter for the robotic group (1 day, $P < .001$) compared with both the conventional laparoscopy group (2 days) and the laparotomy group (4 days). There were no differences in the total number of LNs removed ($P = .26$) or the parametrial size or vaginal cuff length, suggesting no compromise in oncologic outcomes. In a similar series of 100 patients, Chen and colleagues demonstrated no difference in DFS for women undergoing robotic-assisted laparoscopy, conventional laparoscopy, or laparotomy. Favorable perioperative complication rates, estimated blood loss, and oncologic outcomes have been confirmed in a number of other series.

Laparoscopic radical trachelectomy has been demonstrated to be a safe and feasible alternative to an open technique. Robotic-assisted laparoscopic trachelectomy has been evaluated in a few small series and case reports. Api and colleagues performed a review of the literature and compared laparoscopic with robotic-assisted tracheectomies. Estimated blood loss ($P < .001$) and length of hospital stay ($P < .001$) were less in the robotic group, but mean operative time was longer ($P < .001$). Median length of excised parametrial tissue was higher in the robotic group ($P < .001$), but median number of LNs removed was higher in the laparoscopic group (22 vs. 32, $P = .02$). There were no differences in obstetric outcomes. Fifteen percent of patients undergoing robotic procedures experienced a complication, compared with 29% of laparoscopic cases. Nick and colleagues compared robotic-assisted radical trachelectomy (12 patients) with open abdominal radical trachelectomy (25 patients) and found decreased blood loss ($P = .0001$) and length of hospital stay ($P < .001$) with the robotic approach. At a median follow-up of 17 months, there were no differences in operating time and no documented recurrences in either group. Owing to the relative rarity of the procedure, large comparisons to other radical trachelectomy techniques have not been performed. The data currently available demonstrate that robotic-assisted radical trachelectomy is safe and feasible in selected patients.

Pelvic and paraaortic lymphadenectomy is a common procedure in gynecologic oncology, but extensive pelvic lymphadenectomy has been associated with lymphedema. Sentinel LN dissection is the standard of care in breast cancer, and introduction of this technique is associated with a significant reduction in postoperative lymphedema. Sentinel LN dissection was first introduced in the management of gynecologic malignancies in 1994 and has since become an acceptable alternative to full lymphadenectomy in the surgical staging of vulvar, endometrial, and cervical cancer. In an early pilot study, Abu-Rustum and colleagues demonstrated a sensitivity of 100% when sentinel LN detection was performed in patients with a preoperative diagnosis of grade I endometrial adenocarcinoma. SENTI-ENDO (SENTinel Node Biopsy for the Management of Early Stage ENDOmetrial Cancer), a large multinational prospective study, was subsequently performed, confirming the high sensitivity (84% per patient, 100% per hemipelvis) of sentinel LN detection in endometrial cancer. The lower sensitivity per patient is likely due to the inclusion of any nonmapping hemipelvis as negative for sentinel LNs, highlighting the importance of systematic nodal dissection on a nonmapping hemipelvis. All of the false-negative specimens also had high-risk histologic characteristics.

Multiple injection sites have been evaluated in endometrial cancer, including hysteroscopic injection near the lesion, subserosal fundal injection, and cervical stromal injection. Hysteroscopic injection has been shown to be feasible; however, it requires an additional procedure and has not demonstrated improved detection of sentinel LNs when compared with cervical injection. Concern has been raised regarding the detection of involved paraaortic LNs when only a cervical stromal injection is used. Studies have demonstrated that subserosal fundal injection and hysteroscopic injection do not increase the rate of paraaortic sentinel LN detection. In addition, the subserosal technique was shown to have a poorer detection rate compared with cervical stromal injection. The risk of isolated paraaortic LN metastases in endometrial cancer patients with negative pelvic LNs is 1% to 2%. Cervical stromal injection obviates the need for another procedure and is associated with a higher detection rate than hysteroscopic or fundal subserosal injection; therefore most surgeons use this technique.

Sentinel LN dissection has been implemented in the evaluation of early-stage cervical cancer, in which the rate of LN metastasis is 0% to 4.8% for stage IA, 17% for stage IB, and 12% to 27% for stage IIA disease. The SENTICOL (Ganglion Sentinel dans le Cancer du Col) trial demonstrated a sensitivity of 92% and a negative predictive value of 98.2% for sentinel LN detection in early-stage cervical cancer.
prospectively evaluated sentinel LN detection rates in early-stage cervical cancer and found that the sensitivity and negative predictive value decreased when tumors were greater than 2 cm in diameter (sensitivity, 90.9% vs. 72.7%; negative predictive value, 99.1% vs. 88.5%).

Application of a sentinel LN mapping algorithm is important in both cervical and endometrial cancer staging. This algorithm includes pathologic ultrastaging of sentinel nodes, the performance of a systematic pelvic LN dissection in any hemipelvis in which mapping fails to show a sentinel node, removal of all mapped LNs, and removal of any enlarged or suspicious nodes, regardless of mapping. Pathologic ultrastaging detects an additional 4.5% of LNs compared with assessment by hematoxylin and eosin. Use of the full algorithm has been shown to lead to a false-negative metastatic nodal detection rate of 2% in endometrial cancer and 0% in cervical cancer.

**Surgical Technique**

**Step 1: Room Setup**

There is more equipment associated with the robotic surgery platform. Therefore, optimizing the room setup is especially important so as not to compromise patient or staff safety. The specific setup depends on the specific operating room, but in general the room should be arranged so that there is a clear view of the patient from the surgeon console, the cords connecting the carts are not on tension, and there is enough space between pieces of equipment for the operating room staff to move safely and efficiently. Ideally, there should be enough space to accommodate docking of the robot in several positions to facilitate a variety of surgical procedures. Extra-long tubing is available for ventilation. Head and neck robotic procedures are usually performed with the patient's head completely opposite the anesthesiologist. An example of the setup used at our institution is depicted in Fig. 26.1.

**Step 2: Patient Positioning**

The patient should be placed in low dorsal lithotomy position after endotracheal intubation. The patient's arms, including the hands, should be tucked at the sides and padded to prevent inadvertent injury when hidden from view under sterile drapes (Fig. 26.2). Most procedures require the steep Trendelenburg position, so measures should be taken at the beginning of the case to prevent the patient from sliding on the operating room
Step 4: Placement of a Uterine Manipulator

Uterine manipulators are frequently used in simple and radical hysterectomies and are beneficial in improving visualization and providing a landmark for the colpotomy. A variety of manipulators are available and can be tailored to the planned procedure. If a colpotomy is planned, manipulators with a cup to fit over the cervix are preferred; these include the RUMI in conjunction with KOH cups (Cooper Surgical) and VCare (CONMED, Utica, New York). If the patient has already had a hysterectomy and delineation of the vaginal cuff is required, vaginal probes or EEA sizers (Medtronic Minimally Invasive Therapies, Minneapolis, Minnesota) can be used. If the manipulator is being placed purely to move the uterus, a Hulka tenaculum or ZUMI (Cooper Surgical) can be used. Some surgeons prefer not to use a uterine manipulator at all. In our experience, uterine manipulators do facilitate hysterectomy. There is no proven oncologic concern associated with the use of uterine manipulation in patients with uterine or cervical cancers. However, it is difficult to place a uterine manipulator in the presence of a large cervical tumor, and in this setting a vaginal probe may be required instead.

The manipulator should be placed after the patient has been prepared and draped. If performing a hysterectomy, 0-Vicryl sutures can be placed in the cervical stroma at the 3- and 9-o’clock positions to aid in placement of the uterine manipulator and removal of the specimen. We have found this to be quite useful, but it is not routinely done by all surgeons who use the robotic platform. Care should be taken to avoid perforating the uterus, especially during a procedure for a uterine malignancy. To obtain an adequate vaginal margin during radical hysterectomy, a colpotomy can be made at the base of the cervical cup or modifications can be made to existing uterine manipulators, as previously described. A uterine manipulator may not be needed for certain procedures owing to the added retraction offered by the robotic fourth arm; this eliminates the added time, cost, and potential morbidity of uterine manipulator placement.

Step 5: Abdominal Entry

Entry into the abdomen should be performed in the manner in which the surgeon is most comfortable. If the surgeon is most comfortable using an open technique to gain access to the peritoneal cavity, this can be done at the camera port if he or she is using the da Vinci S or Si system. Because the da Vinci Xi system has a smaller camera and all trocars are 8 mm, an open technique is difficult, especially in obese patients. A 12-mm accessory port placed at the Palmer point is often useful during the procedure and can be used as the initial point of access if the surgeon prefers an open technique.

Step 6: Trocar Placement

The trocars should be arranged in an arc toward the operative field (in this case, the pelvis) (Fig. 26.4). With the da Vinci S and Si systems, the trocars must be at least 10 cm apart at approximately a 30-degree angle. The incisions for these ports should be 8 mm wide with the exception of the camera port, which should be 12 mm wide. If the da Vinci Xi system is used, the trocars can be placed in a straight line and need be only 8 cm apart. All da Vinci Xi trocars are the same size because of the smaller camera, and 8-mm incisions should be made for all port sites. An accessory port can be placed in the left upper quadrant or in the suprapubic region. In general, the left upper quadrant is easier for the bedside assistant to access.
As in conventional laparoscopy, trocars should be placed under direct visualization whenever possible. Limited trocar use may be considered, depending on the type of procedure and the surgeon’s experience (Fig. 26.5).

If a paraaortic LN dissection is planned, adjustment of the trocar placement may be necessary in order to adequately reach the paraaortic region. With the da Vinci S and Si systems, the ports can be placed more cranially in the same configuration. Alternatively, trocars may be placed as in an upper abdominal procedure (described in the next section). The da Vinci Xi system allows more freedom of movement, and the dissection can be carried up to the inferior mesenteric artery by using the pelvic trocar arrangement. If a dissection to the renal veins is planned, the robotic arms may be rotated 180 degrees directed toward upper abdomen, without rotating the patient.

We no longer feel that “high” abdominal placement of trocars is necessary, irrespective of the robotic platform used. In general, placement of the camera trocar at the umbilicus is adequate in most cases. If higher abdominal procedures are required, such as infrarenal paraaortic nodal dissection, it is preferable to rotate the patient and dock over the shoulder or rotate the arms on the da Vinci Xi system rather than placing the trocars high. Placement at the umbilicus depends on patient body habitus and may be highly variable, especially in the morbidly obese. As a rule of thumb, the camera trocar is placed at the umbilicus, as long as it is a minimum of 15 cm from the symphysis pubis. Other trocars are placed then, with the planned camera trocar site as reference.

We prefer to use two robotic instruments to the right of the camera trocar and one to the left, with the assistant trocar also to the left. This configuration allows the surgeon to have two opposable grasping instruments; a bipolar grasping instrument is placed in the left-sided trocar, and another is placed in one of the right-sided trocars. (This applies to right-handed surgeons and may be reversed for a left-handed surgeon if necessary.) Some use two robotic instrument trocars on the left side. In this scenario, when both are grasping instruments, it allows for one instrument to be used at a time or else requires switching of instruments from one side to the other as needed.

**Step 7: Examination of the Upper Abdomen**

The upper abdomen should be examined to evaluate for any disease outside of the pelvis. If biopsies are required in the upper abdomen, these can be performed with conventional laparoscopic equipment at this time.

**Step 8: Docking**

The patient should be placed in a steep Trendelenburg position before docking, and the bowel should be swept out of the pelvis as much as possible to improve visualization. Docking can be performed in a variety of positions depending on surgeon preference and the procedure being performed. For pelvic procedures, the robot can be docked in the center, offset center, or on the side (Fig. 26.6). Center and offset center docking refers to placement of the robot between the patient’s legs (Fig. 26.6A). Offset center docking involves placement of the boom of the patient cart between the patient’s legs but not directly in the midline (Fig. 26.6B), thus allowing the assistant access to the perineum. Center docking can be more challenging but permits increased access to the upper paraaortic LN region. Side docking is more commonly used because it provides the greatest perineal access and adequate access to the pelvis and lower paraaortic region and is easier to perform (Fig. 26.7). When the da Vinci S and Si systems are used, the base of the patient cart can be either parallel to the operating table (Fig. 26.7A) or rotated slightly toward the patient (Fig. 26.7B). Either works well as long as the camera can be docked. Because of the enhanced range of motion of the robotic arms in the da Vinci Xi system, the best docking method is on the side, with the base of the patient cart perpendicular to the operating table. The flexibility of the da Vinci Xi system permits a much greater range of docking.

**Step 9: Instrument Selection**

A number of robotic instruments are available and can be used in gynecologic oncology procedures. A select few will be discussed here. It is helpful to have both a monopolar and a bipolar cautery instrument, typically placed in robotic arms one and two. The monopolar instruments available are the Hot Shears Monopolar Curved Scissors, the Permanent Cautery Hook, and...
the Permanent Cautery Spatula. The Monopolar Curved Scissors provide more versatility because they can be used to cut tissue without cautery and, when closed, provide blunt dissection similar to that of the Cautery Hook or the Cautery Spatula. A variety of bipolar cautery instruments are available. In our experience, the two most commonly used are the Maryland Bipolar Forceps and the Fenestrated Bipolar Forceps. Both have advantages and disadvantages. The Maryland Bipolar Forceps are better for dissection and working in small areas; however, they have less cautery area, and tissue slips more easily from them. The Fenestrated Bipolar Forceps, on the other hand, are not as useful for dissection and are more difficult to use in small spaces; however, they have a large cautery area and grasp tissue well. The Vessel Sealer is also available for cauterizing larger vessels, but it is bulky and not as useful for dissecting or grasping tissue. Noncautery forceps are also available and are frequently used in the robotic fourth arm to aid with retraction. The two used the most by us are the ProGrasp Forceps and the Cadiere Forceps. The Cadiere Forceps have less grasping force and are more difficult to use on heavy or tough tissue. The ProGrasp Forceps have more grasping force but must be used with caution when grasping delicate tissue. The choice of instruments should be based on patient and procedure specifics, as well as surgeon preference and comfort.

Step 10: Procedure

Once the robot is docked and the instruments inserted, the steps for robotic-assisted procedures are the same as for conventional laparoscopy and laparotomy. Sentinel LN dissection should be performed before the hysterectomy. When both colorimetric and immunofluorescent dyes are used, approximately 10 to 20 minutes are required from time of injection to sentinel LN detection.87

If an omentectomy is planned, it can usually be accomplished by using the setup for a pelvic procedure. In general, the inferior aspect of the omentum can be grasped and pulled into the pelvis without repositioning the patient or the robot. Insertion of the 30-degree down laparoscope may aid visualization. If there is difficulty with visualization, the robot may be undocked and the patient moved to a less acute angle of Trendelenburg to facilitate bringing the omentum into the pelvis. If there are still problems accessing the omentum, the patient may be rotated.

**FIG. 26.6 Center and Offset Center Docking.** Options for docking the da Vinci S and Si systems for pelvic procedures. (A) Diagram of center docking. (B) Diagram of offset center docking. (Robot base in green.) (C) Intraoperative example of offset center docking.

**FIG. 26.7 Side docking for the S/Si and Xi systems with the base of the robot parallel to the operating table (A) and rotated slightly toward the operating table (B) (intraoperative example [C]). The Xi system may also be docked with the base of the robot perpendicular to the operating table as shown in Fig 26.11C.
and the robot docked over the patient’s shoulder, as described in the next section for upper abdominal procedures. If the da Vinci Xi system is used, the arms may be rotated and docked toward the upper abdomen.

**Step 11: Specimen Removal**

As in conventional laparoscopy, there are several techniques for removing the surgical specimen. The goal is to remove the specimen while containing any cancerous cells. If the uterus, cervix, bilateral ovaries, and fallopian tubes are not pathologically enlarged, they can be removed through the colpotomy incision. If the specimen is too large to be removed safely through the colpotomy, any large laparoscopic bag can be placed through the vaginal incision, and the uterus may be sectioned in the bag with a scalpel. Another option is the creation of a mini-laparotomy, typically transversely in the suprapubic position. Pelvic lymphadenectomy is frequently performed before hysterectomy; therefore the colpotomy is not available for specimen removal. LNs may be removed through an accessory trocar with a laparoscopic spoon, or they may be placed in a laparoscopic bag or bags for removal through the colpotomy once the hysterectomy is complete.

**Step 12: Vaginal Cuff Closure or Cerclage Placement—Instrument Selection**

In robotic-assisted suturing, the two cautery instruments may be exchanged for two needle drivers. The Mega SutureCut and Large SutureCut have sharp edges at the crux of the instrument, allowing them to cut suture in addition to driving the needle. If using these instruments, however, the surgeon should be mindful that the suture is not accidentally cut during suturing. To avoid this complication, the Large Needle Driver or Mega Needle Driver may be used instead. Alternatively, the instrument in the surgeon’s dominant hand (usually the monopolar cautery device) may be the only one exchanged for a needle driver, and the bipolar cautery device may remain in place in the other arm. This is sometimes preferable because, compared with a needle driver, it is superior at grasping tissue and can be used to cauterize any bleeding that occurs during suturing.

**Step 13: Removing the Trocars**

After the procedure is complete and adequate hemostasis has been achieved, the instruments may be removed and the robot undocked and moved away from the patient. As in conventional laparoscopic procedures, the trocars should be removed under direct visualization.

**Step 14: Abdominal Incision Closure**

The risk of herniation is very low when the 8-mm robotic incisions are used, and these do not require fascial closure. If these trocars were not placed perpendicular to the fascia, however, consideration should be given to closing the fascia, because it is likely that the 8-mm fascial incision was enlarged with trocar movement during the procedure. The fascia should be closed in any larger incisions, such as the 12-mm camera port for the da Vinci S or Si system or any accessory ports larger than 10 mm. Various fascial closure methods are used. Our typical approach for entry into the abdomen is to use the open Hasson technique at the camera trocar site when the da Vinci S or Si system is used. Sutures can be placed on the fascia at this time, which can then be simply tied at the end of the procedure. Direct fascial closure of the camera site is also feasible, and this is how we prefer to close this fascia if the sutures were not placed initially or are not felt to result in sufficient closure. Alternatively, a device such as the Carter-Thomason (CooperSurgical, Inc, Trumbull, Connecticut) can be used to close the fascia on larger port sites. The Carter-Thomason comes in both disposable and reusable forms, both of which function similarly. A free tie of the suture chosen for fascial closure is doubled, creating a loop. A hemostat or similar clamp is placed on the free ends to avoid losing the suture in the abdomen. The loop is loaded into the jaw of the Carter-Thomason, and the instrument is advanced through the fascia at one edge of the incision under direct visualization. A Maryland or other laparoscopic grasper is used to grasp the suture while the Carter-Thomason is opened to release the suture. The Carter-Thomason is then removed. It is important that the jaw of the instrument be closed before removal to avoid tissue damage. The closed Carter-Thomason is then reintroduced through the fascia on the other side of the incision under direct visualization, the jaw is opened, and the suture is placed inside. The jaw is then closed and the Carter-Thomason is removed with the end of the suture. The suture is then tied, closing the fascial defect. The method of fascial closure should be chosen based on surgeon comfort, specific patient and incision characteristics, and equipment availability.

**Surgical Techniques—Upper Abdominal Procedures**

**Indications**

In general, upper abdominal procedures are performed in the setting of ovarian cancer, but they are occasionally undertaken for other malignancies. Data exist on robotic-assisted ovarian cancer staging and primary and interval debulking, as well as the management of recurrent disease. These data are reviewed in this section.

Research on the use of robotic surgery in the primary surgical management of ovarian cancer is limited and has been reported in only a few small series. Brown and colleagues described a series of 26 patients with presumed early-stage ovarian cancer who subsequently underwent staging via robotic-assisted laparoscopy. The mean operative time was 2.9 hours (95% confidence interval [CI], 2.69–3.11), and mean estimated blood loss was 63 mL (95% CI, 60.0–74.77). There were no intraoperative complications or conversions to laparotomy. The mean numbers of pelvic and paraaortic LNs removed per patient were 14.6 (95% CI, 12.7–16.5) and 5.8 (95% CI, 4.78–6.92), respectively. All patients were diagnosed with either stage I or stage II disease. Two patients had postoperative complications; one was readmitted with a wound infection and the other with a vaginal dehiscence. Another series compared 63 robotic versus 26 laparotomy cases involving primary staging or interval debulking. Operative time was longer for the robotic group (P < .0001), but blood loss and length of hospital stay were lower (P < .0001 and P = .0009, respectively). Major complication rates, lymphadenectomy yield, and optimal debulking rates were similar between the two groups. At 1 year, there was no difference in rates of survival or recurrence.

Two series have compared robotic surgery with both laparoscopy and laparotomy. The first, reported by Magrina and colleagues in 2011, compared robotic-assisted primary surgical management of ovarian cancer with conventional laparoscopy and laparotomy in a retrospective case-control study. Twenty-five patients managed by primary robotic-assisted laparoscopy were matched by age, body mass index (BMI, kg/m²), and types
and numbers of procedures with patients treated by conventional laparoscopy (27 patients) and laparotomy (119 patients). Patients were divided into three groups based on the extent of the operation performed. Type I patients underwent primary surgical therapy consisting of hysterectomy, bilateral salpingooophorectomy, omentectomy, pelvic and paraaortic lymphadenectomy, and removal of any metastatic peritoneal disease. Type II patients underwent the same procedures as type I patients, with the addition of one major procedure, defined as any type of intestinal resection, full-thickness diaphragm resection, resection of liver disease, and splenectomy. Type III patients were treated with the same procedures as type I patients but with two or more additional major procedures. The majority of patients had stage III or IV disease (60% in the robotic group, 75% in the laparoscopy group, and 87% in the laparotomy group). Similar percentages of each group underwent interval debulking procedures (24.0% in the robotic group, 29.6% in the laparoscopic group, and 24.3% in the laparotomy group). Operating time was significantly longer for the robotic group compared with the laparoscopy and laparotomy groups (P = .009). Estimated blood loss (P < .001) and length of stay (P < .001) were significantly lower in the robotic and laparoscopic groups compared with the laparotomy group. There was no difference in OS among groups. When the data were examined with respect to debulking group (type I, II, or III), length of stay and estimated blood loss were improved in the robotic and laparoscopy groups for type I and II debulking. No patients in the type III group underwent a conventional laparoscopic surgical procedure. In the type III group, estimated blood loss and rates of intraoperative complications were lower in the robotic group, but operating time was longer, and there was no difference in length of stay or postoperative complications. This study demonstrates the safety and feasibility of robotic surgery in the primary management of all stages of ovarian cancer. However, the authors concluded that laparotomy may still be preferable to robotic surgery for patients requiring several major procedures (type III patients). There is likely little use for the robotic platform in upfront debulking procedures requiring extensive multiquadrant resections.

Chen and colleagues reported a series of 44 patients who underwent robotic-assisted staging for the treatment of epithelial ovarian cancer and borderline ovarian tumors, comparing these with cases performed with conventional laparoscopy (21 patients) and laparotomy (73 patients). Patients who required any major procedures in addition to hysterectomy, bilateral salpingooophorectomy, and pelvic and paraaortic lymphadenectomy were excluded. There were no differences in patient characteristics between groups. Optimal debulking rates were not significantly different, with 100% optimal debulking achieved in both the robotic and laparoscopic groups and 98.6% achieved in the laparotomy group (P = .64). In their cohort, operative time (P = .001), estimated blood loss (P < .001), length of hospital stay (P < .001), and time to resumption of solid diet (P = .001) all favored robotic and laparoscopic approaches over laparotomy. Postoperative pain was significantly less in the robotic group compared with the laparoscopic and laparotomy groups (P < .001). There was no difference in complications rates (P = .13), DFS (P = .44), or OS (P = .35) between groups. This suggests that in carefully selected patients, primary surgical management of ovarian cancer with a robotic-assisted approach is feasible.

Use of robotic surgery has also been evaluated in the setting of recurrent ovarian cancer, although the data remain limited. Escobar and colleagues described a multiinstitutional series of 48 patients undergoing planned robotic-assisted laparoscopic management of recurrent ovarian cancer. All patients had a platinum-free interval of at least 6 months from the time of initial adjuvant treatment, and none had carcinomatosis. Pelvic and upper abdominal procedures were performed, including bowel resection, splenectomy, and liver and diaphragm resection. The operation was completed robotically in 44 patients, with a median estimated blood loss of 50 mL and a median operative time of approximately 3 hours. The majority of patients (63.6%) were discharged either on the day of operation or the following day, and in 82% optimal cytoreduction was achieved (defined as no gross residual disease). In the four cases in which conversion to laparotomy was required, there were no differences in preoperative factors compared with procedures performed robotically. With a median follow-up of 28.1 months, the median PFS was 21.4 months, and median OS was 50.1 months.

A small single-institution series reported by Magrina and colleagues compared outcomes of secondary cytoreduction by conventional laparoscopy (9 patients), robotic-assisted laparoscopy (10 patients), and laparotomy (33 patients). Patients whose preoperative imaging showed extensive recurrent disease were not included in any of the groups, and all patients had at least a 12-month platinum-free interval. Major procedures were performed when necessary, including bowel resection, diaphragm resection, splenectomy, and liver resection. There were no demographic differences or any differences in the number of procedures performed among the three groups. Estimated blood loss (P < .0001) was greater and hospital stay (P = .0002) longer in the laparotomy group. There were no differences in intraoperative or postoperative complications, OS, or PFS among the three groups. These data indicate that, in carefully selected patients with recurrent disease, robotic surgery may provide advantages including less blood loss and shorter hospital stay.

Although limited, the literature regarding robotic-assisted management of ovarian cancer supports its use in carefully selected patients. Patients being considered for robotic-assisted staging or debulking should undergo adequate preoperative evaluation including imaging of the chest, abdomen, and pelvis. This will facilitate the decision-making process regarding the surgical procedure(s) required to achieve optimal cytoreduction and will help the surgeon determine whether or not a minimally invasive approach is feasible.

**Surgical Technique**

**Step 1: Room Setup**

If the da Vinci Xi system is used, the room setup is the same as previously described for a pelvic procedure. If the da Vinci S or Si system is used, the anesthesia equipment and team should be located on the patient’s side to allow for docking over her shoulders.

**Step 2: Patient Positioning**

For an upper abdominal procedure, the patient should be positioned in the dorsal lithotomy position and padded, as previously described for a pelvic procedure. Padding should be used to ensure that the patient will not slide because she will be in a steep reverse Trendelenburg position.

If a splenectomy is planned, the patient should be positioned in the right lateral decubitus position with the operating room table in a slight reverse Trendelenburg position. The patient’s back should be arched 30 degrees to open the space between the costal margin and the iliac crest (Fig. 26.8).
Step 3: Abdominal Entry

The abdominal entry should be performed as previously described.

Step 4: Trocar Placement

Trocar should be placed as depicted in Fig. 26.9. If a splenectomy is planned, the trocars should be placed in an arc facing the left upper quadrant (Fig. 26.10). As mentioned previously, we prefer to place two robotic arms to the right of the camera trocar and one to left, regardless of which quadrant is being accessed.

Step 5: Docking

The patient should be placed in steep reverse Trendelenburg position before docking, and bowel should be swept from the operative site as much as possible. With the da Vinci S or Si system, the robot should be docked over the patient’s shoulder (Fig. 26.11). With the 180-degree rotational capability of the robotic arms, perpendicular side docking can be performed as previously described for a pelvic procedure.

Step 6: Instrument Selection

The same instruments described for use in the pelvic procedure are also used in the upper abdominal procedures. If performing a splenectomy, ligation of the splenic vessels should be done using a vessel sealer, which provides more control during this critical step than the other bipolar cautery instruments. Robotic vascular clips may also be used for smaller accessory vessels as per surgeon preference.

If a bowel resection is planned, robotic staplers are available for the da Vinci Si and Xi models. With the da Vinci S model, a laparoscopic stapler may be used by a bedside assistant through an accessory port.

Step 7: Procedure

As in pelvic procedures, the steps to robotically performed upper abdominal procedures are the same as in conventional laparoscopy or laparotomy. For bowel resection, considering the availability of staplers and the ease of intracorporeal suturing afforded by the robotic system, the anastomosis should be completed intracorporeally.

Step 8: Specimen Removal

Specimens should be removed through a mini-laparotomy. Mini-laparotomy may be performed by extending one of the trocar incisions; alternatively, it may be performed separately by making a transverse incision in the suprapubic position. The spleen, in particular, should not be morcellated outside of a bag, because this could lead to splenosis and spread or recurrence of disease.

Steps 9 and 10: Trocar Removal and Abdominal Incisional Closure

Trocar removal and abdominal incision closure can be performed as previously described for pelvic procedures.

Surgical Techniques—Multiquadrant Procedures

Most of the steps in multiquadrant procedures are performed as previously described. Those that are different are described in the following sections.

Trocar Placement

With the da Vinci S or Si models, the trocars should be placed as previously described for both a pelvic and an upper abdominal
procedure. Some trocars may be used in both the pelvis and the upper abdomen; however, it is likely that additional trocars will be needed. If the da Vinci Xi system is used, trocars can be placed in a straight line across the center of the abdomen and can be used for both the pelvic and upper abdominal procedures.

**Docking**

Docking can be performed as described for either the pelvic or the upper abdominal procedure, depending on which procedure will be performed first. Moving from the pelvis to the upper abdomen (and vice versa) requires repositioning. Moving from a pelvic procedure to an upper abdominal procedure is described here.

With the da Vinci S or Si model, the patient must be rotated. With advance communication between the surgical team and the anesthesia team, this can be accomplished smoothly. Instruments should be removed, the robot undocked, and trocars removed. A sterile transparent wound dressing (such as Tegaderm [3M, Maplewood, Minnesota]) should be placed over the incisions and the drapes removed. The patient is then rotated 180 degrees. The patient is prepared and the drapes are replaced; the wound dressing is removed, and the trocars are replaced. At this time, new trocars may be placed depending on what is required for the remainder of the procedure. The robot is then docked over the patient’s shoulders and the procedure is continued.

With the da Vinci Xi model, only the robotic arms will need repositioning; rotation of the patient is not necessary. The boom housing the robotic arms on the da Vinci Xi system is capable of rotating 180 degrees; if the Xi model is used, docking is performed as previously described for a pelvic procedure.

When rotating the patient or the robotic arms, it is important to remember that, in this configuration, the fourth robotic arm is located on the opposite side of the patient. This can be disorienting if the surgeon is accustomed to two robotic arms on the other side. If an accessory port has been placed, this issue can be resolved by switching the accessory port trocar and the trocar for the fourth robotic arm.

**Special Considerations**

**Pelvic Exenteration**

First described by Alexander Brunschwig in 1948, pelvic exenteration is indicated for the locoregional treatment of advanced or recurrent pelvic cancer, typically endometrial, cervical, and vulvar. The operation can be tailored, depending on
location of disease, into an anterior, posterior, total, suprarelevator, or infralevator exenteration. Although modification of the procedure has been shown to decrease complication rates,\textsuperscript{112} rates of serious morbidity and mortality remain high.\textsuperscript{113} Reports of robotic-assisted pelvic exenteration for gynecologic malignancies are available and demonstrate feasibility in carefully selected patients.\textsuperscript{114–119} In 2009 Peter Lim authored the first case report of a robotic-assisted total pelvic exenteration. The operative time was 375 minutes, estimated blood loss was 375 mL, and the patient experienced no intraoperative or postoperative complications.\textsuperscript{117} Davis and colleagues described two patients with recurrent cervical cancer treated with robotic-assisted anterior pelvic exenteration. Mean operating time was 9 hours, and mean estimated blood loss was 550 mL. Both patients were discharged home on postoperative day 8.\textsuperscript{116} In the largest series to date, Puntambekar and colleagues described 10 patients with advanced or recurrent cervical cancer treated with anterior pelvic exenteration. Mean operative time was 180 minutes, and mean estimated blood loss was 110 mL. There were no intraoperative or postoperative complications, and none of the patients required conversion to laparotomy. With a median follow-up of 11 months, 66.7% were disease free.\textsuperscript{118} Although these data suggest that robotic-assisted pelvic exenteration is feasible, the procedure requires significant skill and experience with complex robotic surgery and should be performed only in carefully selected patients by surgeons capable of completing the operation.

**Obesity and Robotic Surgery**

Obesity, defined as a BMI greater than 30 kg/m\textsuperscript{2}, is a major health concern in the United States, where an estimated 34.9% of all adults are reportedly obese.\textsuperscript{120} In addition to the multitude of general health complications caused by obesity, it is also a major cause of surgical morbidity and can add complexity to any planned procedure. The decreased infectious complications conferred by MIS make it especially attractive for the obese patient. Robotic surgery has provided an opportunity to expand the use of MIS in this population.\textsuperscript{121,122} Both the positioning and required access to the abdominal cavity necessary in robotic gynecologic oncology surgery, however, can make operating on obese women technically difficult.

Obesity in gynecologic oncology is most prevalent in the endometrial cancer population. Robotic surgery provides an opportunity for the MIS approach in obese and morbidly obese patients. As previously discussed, MIS staging in endometrial cancer is associated with shorter hospital stay, less blood loss, and comparable oncologic outcomes.\textsuperscript{3} In a retrospective series, Gehrig and colleagues compared robotic-assisted versus conventional laparoscopic endometrial cancer staging in obese (BMI >30 mg/m\textsuperscript{2}) and morbidly obese (BMI >40 mg/m\textsuperscript{2}) patients. For both the obese and morbidly obese patients, robotic-assisted staging was associated with decreased length of hospital stay ($P = .0119$), decreased blood loss ($P < .0001$), increased LN retrieval ($P = .004$), and shorter operative time ($P = .0004$).\textsuperscript{123} Other studies have shown a decreased risk of BMI-based conversion to laparotomy with robotic surgery versus conventional laparoscopic surgery,\textsuperscript{124} whereas the GOG LAP2 trial demonstrated an increasing risk of conversion with increasing BMI when conventional laparoscopy was performed.\textsuperscript{3} Other studies have shown no differences in length of hospital stay, wound complications, or robotic console time with increasing BMI when the robotic platform was used for endometrial cancer staging.\textsuperscript{125} Leitao and colleagues reported that with the introduction of robotic-assisted laparoscopy there was an increased use of the minimally invasive approach in surgical staging for morbidly obese endometrial cancer patients and an attendant decrease in estimated blood loss, length of hospital stay, and postoperative complications.\textsuperscript{126} When performing robotic-assisted surgical procedures on an obese woman, the surgeon must consider the following: First, positioning of the obese patient requires careful consideration. The operating table specifications should be checked to ensure that the table will support the weight of the patient. The patient should be placed in a dorsal lithotomy position as previously described, but stirrups specifically designed for large or obese patients should be used to minimize the risk of nerve injury or compartment syndrome. Even if the operating room table will support the patient’s weight, it will likely not be wide enough to accommodate the patient’s width with the arms tucked. Extensions can be used to enlarge the operating table while retaining the position required for robotic surgery. Arm sleds are frequently used to support and hold the patient’s arms at the sides while protecting them. Special attention should be paid to ensure that the patient is appropriately padded and does not sustain any nerve injuries from unexpected compression, from either the initial positioning or the robot itself after docking. The steep Trendelenburg position should be tested before draping to ensure that the patient does not slide on the table.

Second, the anatomy of the abdominal wall is distorted in the obese patient. Accordingly, the “umbilical” trocar will not be placed in the umbilicus but at a position estimated by bony landmarks (the pubic symphysis and costal margin) (Fig. 26.12). Care should also be taken when placing trocars because it may be difficult to clearly see the inferior epigastric vessels owing to increased preperitoneal fat. Longer trocars (made by Intuitive
Surgical specifically for obese patients) may be required to adequately traverse the abdominal wall. Once abdominal entry is achieved, pneumoperitoneum is created. The same intraabdominal pressures used in thinner patients may not be enough to provide adequate visualization; however, it is unlikely that an obese patient will tolerate higher pressures without compromise of vascular return or respiratory status. Similarly, the patient may not be able to tolerate the same degree of Trendelenburg because of respiratory compromise. An assistant may need to use a laparoscopic bowel grasper or fan to provide adequate visualization.

Finally, if operating in the pelvis of a patient with an intact uterus, a uterine manipulator should be placed at the beginning of the procedure. Because of factors limiting visualization in this population, proper uterine manipulation is critical in order to achieve visualization and complete the procedure.

Robotic surgery is feasible in obese and morbidly obese patients, however, and offers them the short-term benefits associated with MIS. Given the decreased risk of wound complications conferred by a minimally invasive approach, MIS should be attempted when possible in these patients.

**Cost of Robotic Surgery in Gynecologic Oncology**

The cost of robotic-assisted laparoscopy has been a subject of debate since its introduction. Numerous cost-analysis studies have been published, frequently with conflicting results because of the methods used.\(^{127}\) It is important to remember that the robotic platform is another tool to assist in accomplishing a minimally invasive procedure. Although it may be more expensive than conventional laparoscopy, especially when considering instrumentation,\(^ {61,128–132}\) both techniques are less expensive and more cost-effective than laparotomy.\(^ {56,126,133,134}\) However, many hospitals have built minimally invasive suites at substantial cost, and none of these costs were considered in the publications to date. Use of MIS in gynecology is increasing, but the reality is that across the country laparotomy still accounts for the majority of hysterectomies performed.\(^ {64,135}\) Leitao and colleagues demonstrated cost savings with the implementation of use of the robotic platform in primary surgical treatment of morbidly obese women with endometrial cancer.\(^ {126}\) Although difficult to quantify, the societal advantages of earlier return to normal activities and decreased reliance on caregivers should be considered in evaluating the cost-effectiveness of minimally invasive procedures. This factor is frequently left out of cost analyses. Barnett and colleagues included lost wages and caregiver costs in their cost comparison of robotic-assisted laparoscopy, conventional laparoscopy, and laparotomy in endometrial cancer staging and found that laparotomy was the most expensive surgical technique.\(^ {133}\) Cost-effectiveness analysis is challenging. However, given the current data demonstrating increased use of MIS with the robotic platform, associated costs may ultimately decrease on both the hospital and society levels.

**Conclusion**

The prevalence of robotic-assisted surgery in gynecologic oncology is increasing as this technology becomes more widely available. Data demonstrate that use of the robotic platform is safe and feasible for a variety of gynecologic oncology procedures. It should be remembered that the robotic platform is a tool for performing a minimally invasive procedure, and its use has been consistently shown to decrease length of hospital admission, intraoperative blood loss, and postoperative complications compared with laparotomy. The performance of a minimally invasive procedure should be the goal, if appropriate. When available and when appropriate, use of the robotic platform should be strongly considered for gynecologic oncology procedures.

**Suggested Readings**


**References**

Section 10 Minimally Invasive Surgery


40. Deleted in review.


49. Lee SJ, et al. The feasibility and safety of same-day discharge after robotic-assisted hysterectomy alone or with other procedures for benign and malignant indications. Gynecol Oncol. 2014;133:552–555.


Minimally invasive surgery has consistently been found to reduce complications compared with open surgery. For patients undergoing a variety of gynecologic procedures, minimally invasive surgery also results in equivalent primary procedural outcomes (e.g., survival outcomes after surgical staging of endometrial cancer, risk of recurrent fibroids after myomectomy). Although minimally invasive surgery has clear benefits, it also has unique risks that surgeons must minimize, anticipate, and adeptly manage when they occur.

### Complications During Abdominal Entry

Injury to the viscera or vasculature during abdominal entry is one of the most common life-threatening complications encountered during minimally invasive surgery. Bowel injury can occur in up to 0.5% of laparoscopic cases, and major vascular injuries are reported to occur in 0.01% to 0.5% of cases. Most of these injuries occur during abdominal entry as opposed to during the laparoscopic procedure. Although rare, these injuries can be fatal. In fact, vascular and bowel injuries, along with anesthesia complications, are the leading causes of death during laparoscopy.

Three methods are commonly used to enter the abdominal cavity and establish pneumoperitoneum. All carry slightly different risks and benefits. Blind entry with a Veress needle is the method most commonly used by many surgeons. In another closed technique, a trocar is inserted under optical guidance without first establishing pneumoperitoneum. This trocar is then used to insufflate the abdomen. In the open technique, as described by Hasson, each layer of the abdominal wall is directly visualized and incised before direct placement of a blunt trocar.

Several studies have suggested the superiority of the open technique, especially when performed through the umbilicus. In 2000, Hasson and colleagues reported their extensive experience with the technique. Over a 29-year period, the authors performed over 5000 open laparoscopies and had no failed entries, no major vascular injuries, and only one small bowel injury related to entry. In contrast, a summary of 1399 reports to the FDA detailed 31 fatalities (almost all due to vascular lacerations) related to bladed or optical trocar injuries.

More recently, a 2015 meta-analysis did not support the advantage of the open technique. The authors identified 46 randomized controlled trials including more than 7000 patients. There was no evidence to support the use of a closed or open technique to prevent entry injuries, although most evidence was of very low quality and there was a lower risk of failed entry with the open technique. Among the closed entry techniques, there was a lower risk of vascular injury and failed entry with direct trocar versus Veress needle entry. In general, it is recommended that surgeons use the entry method with which they have the most comfort, recognizing that all techniques carry risk of injury.

### Vascular Injuries at Abdominal Entry

Once a vascular injury has occurred, it is important for the surgeon to quickly identify such injury and address it immediately. The presentation can be dramatic and catastrophic if unrecognized, with mortality approaching 15%. The most common sites of injury are the infrarenal aorta and right common iliac vessels. In thin patients, the aorta can be 2 cm from the umbilicus. The right common iliac traverses from its origin at the aorta to the right at the level of the umbilicus, which makes it prone to injury as well. Whereas some patients may have obvious hemoperitoneum, in others it may not be readily apparent, especially if blood dissects through the retroperitoneum. Patients who develop unexplained hypotension or tachycardia should have unrecognized vascular injury in the differential diagnosis.

Laparoscopic repair of vascular injuries is dependent on the location and severity of the injury and hemodynamic status of the patient. Any patient with a known or suspected vascular injury with signs of hemodynamic instability should undergo immediate laparotomy, with pressure applied to the injury until the patient’s condition can be stabilized, appropriate instruments obtained, and, in most cases, vascular surgery consultation requested. For injuries to vessels smaller than 1 to 2 mm, insertion of a laparoscopic sponge and application
of pressure for 2 minutes may be adequate to allow clotting to occur. For intermediate injuries in which the patient remains hemodynamically stable, the most important consideration for laparoscopic repair remains close communication with anesthesia staff. If pressure can be applied to the injury with either direct compression or an atraumatic grasper, the surgical team can obtain necessary instruments, suture, and blood products to facilitate closure. Availability of a capable surgical assistant to keep the site free of blood is also essential. This may necessitate placement of additional laparoscopic port sites to allow for additional access to the surgical field. Once fully prepared, small injuries can be closed with 5–0 polydioxanone (PDS) suture, with care taken to avoid excessive traction on the defect during suturing. Larger injuries can also be repaired after distal and proximal control is obtained with laparoscopic vascular clamps, although this should generally be performed by a surgeon experienced with laparoscopic repair of vascular injuries. As with other injuries, the emphasis should be placed on safely completing the repair rather than avoiding conversion to laparotomy at all costs.

Damage to minor vessels in the abdominal wall can also occur during lateral port placement. Although generally less severe than injury to retroperitoneal vessels, injury to the inferior epigastric vessels can lead to morbidity due to reperfusion, blood transfusion, and conversion to laparotomy. The inferior epigastric arteries lie at the lateral border of the rectus abdominis muscles in the lower abdominal quadrants and are usually injured during lateral port placement. Direct visualization of lateral port placement with transillumination of the abdominal wall before placement can prevent many of these injuries. Bleeding from the inferior epigastric vessels can be treated with direct suture ligation, full-thickness abdominal wall mattress sutures, or tamponade with a temporary Foley balloon.

Bowel Injuries at Abdominal Entry

As reviewed elsewhere in the chapter, the main risk of bowel injury results from delayed recognition and subsequent peritonitis and sepsis. The bowel and omentum underlying all trocar sites should be examined immediately on entry into the peritoneum. Repeat examination of the entry site should be performed after a second port is inserted to help identify any loops of bowel that are adherent near the original entry site that may have inadvertently been injured. If a “through-and-through” bowel injury is encountered during trocar placement, the injured bowel should be left attached to the trocar until additional ports have been placed to facilitate repair. This is a critical point: Once the bowel has been removed from the trocar, the injury often decreases in size and can be more difficult to identify. Insufflation tubing should be connected to an alternate port before removal to prevent dissection of the bowel wall while the trocar is being withdrawn.

Prevention of vascular and gastrointestinal injuries is of utmost importance. Decompression of the stomach and bladder before the procedure is started will help keep the operating field clear. When possible, prior incisions should be avoided because abdominal entry points are often a site of adhesion formation. This is particularly true if mesh was used during the closure of the previous incisions. If extensive abdominopelvic adhesions are anticipated, the surgeon may elect to use a left upper quadrant approach through the Palmer point, where adhesions tend to be less common.

### Laparoscopic Bowel and Urinary Tract Injuries

Unintended injuries to nongynecologic organs occasionally occur during minimally invasive surgery but are a primary cause of life-threatening complications. Given the importance of these issues, the identification and management of gastrointestinal and urinary tract injuries are addressed in detail in Chapters 18 and 19, respectively. This section focuses briefly on the elements of minimally invasive surgery that put these structures at risk.

#### Mechanism of Thermal Injuries

To an even greater extent than during open procedures, the use of electrosurgery is vital to the success of most minimally invasive procedures. The often subtle and delayed impact of electrosurgical injuries during laparoscopy makes recognition more difficult. In fact, the full extent of damage may not be apparent until several days after the operation. Thermal injury is associated with a progressive zone of tissue destruction that extends beyond the area, if any, identified at the time of the procedure. This leads to subsequent tissue necrosis and possible viscus perforation 72 to 96 hours after the initial injury. This is of utmost importance for the bowel, because delayed recognition and/or development of bowel perforation is a major source of morbidity and mortality in laparoscopic surgery. If abdominal pain continues to worsen after the operation, especially if accompanied by tachycardia and fever, a bowel injury should be suspected. Because of these potentially life-threatening complications, surgeons must have a thorough understanding of the lateral thermal spread that any device they are using will cause. Some examples of commonly used devices are listed in Table 27.1.

#### Preventing Gastrointestinal Tract Injuries

Although not all injuries are preventable, good surgical practice can mitigate risk. This begins with an understanding of when injuries are most likely to occur. For example, most bowel and vascular injuries occur at the time of abdominal entry. As discussed earlier, meticulous attention to technique during abdominal entry is essential. In addition, appropriate traction when lysing adhesions can reduce the risk of bowel injury during sharp or electrosurgical dissection. If bleeding occurs near gastrointestinal structures, it is best controlled with mechanical means such as with pressure or by suture ligation rather than electrocautery.

#### Laparoscopic Repair of Gastrointestinal Tract Injuries

If an injury to the gastrointestinal tract is identified during laparoscopy, the area should be either repaired immediately or tagged with suture to facilitate later identification. Small

### Table 27.1 Expected Thermal Spread Associated With Common Electrosurgical Devices

<table>
<thead>
<tr>
<th>Device</th>
<th>Thermal Spread</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional bipolar</td>
<td>2 to 22 mm</td>
</tr>
<tr>
<td>Ultrasonic device</td>
<td>0 to 3 mm</td>
</tr>
<tr>
<td>EnSeal</td>
<td>1.1 mm</td>
</tr>
<tr>
<td>LigaSure (10 mm)</td>
<td>1.8 mm</td>
</tr>
<tr>
<td>LigaSure (5 mm)</td>
<td>4.4 mm</td>
</tr>
</tbody>
</table>

LigaSure—Medtronic, Minneapolis, Minnesota. EnSeal—Ethicon, Bridgewater, New Jersey.
superficial thermal injuries and full-thickness injuries a few millimeters in diameter can be oversewn laparoscopically with 3-0 silk suture. Larger injuries require resection of the involved segment. An experienced laparoscopic surgeon may be able to perform primary small bowel resection and anastomosis laparoscopically. For surgeons who are more comfortable with open bowel surgery, a midline incision can easily be extended a few centimeters to allow for exteriorization of the injured segment and resection using conventional open techniques. If this approach is used, it is often best to tag the injured segment, complete the laparoscopic procedure, and extend the midline camera incision to facilitate repair of the bowel injury at the time of abdominal closure.

Preventing Urinary Tract Injuries

The urinary tract is also susceptible to injury during gynecologic procedures owing to its close anatomic relation to other pelvic organs. Several studies have found that the incidence of urinary tract injury is greater with minimally invasive surgery than with an open approach. This is likely related to a combination of factors, including the increased use of electrosurgery in minimally invasive approaches and the loss of perspective that can occur under the magnification of laparoscopy, especially for inexperienced surgeons. Identifying the location of the ureter is the most important step for avoiding injury. In general, the use of electrosurgical devices should be avoided when in close proximity to the ureter. This is most critical during gonadal vessel ligation and uterine artery ligation, where the ureter runs close to the operative field. As with bowel injury, thermal damage to the ureter may go unrecognized for several days to weeks; thus, judicious use of electrosurgery is recommended.

Detection of Urinary Tract Injuries

It is estimated that 25% to 50% of urinary tract injuries may be unrecognized at the time of operation. The detection rate increases to 80% to 90% if cystoscopy is performed. Therefore AAGL recommends that surgeons consider cystoscopy at the time of laparoscopic hysterectomy. Cost-effectiveness of routine cystoscopy is unclear, especially in settings where baseline urethral injury rates are low. Accordingly, the practice has not achieved universal acceptance. When cystoscopy is performed, failure to see efflux of blue dye 20 to 30 minutes after administration should raise the concern for ureteral injury. Follow-up studies could include intraoperative intravenous pyelogram, retrograde ureteropyelogram, or ureteral catheter placement. It is important to note that intraabdominal observation of ureteral vermiculation does not preclude the possibility of ureteral injury.

Although cystoscopy will permit detection of most transection and ligation injuries to the ureter and bladder, it is important to appreciate that cystoscopy will not reveal most thermal injuries to the ureter. Regardless, cystoscopic identification of urinary tract injuries may mitigate the need for reoperation and prevent the sequelae of long-term renal damage.

Laparoscopic Repair of Urinary Tract Injuries

Laparoscopic repair of urinary tract injuries can be complex, given the three-dimensional nature of these structures. Repair of bladder dome injuries should be completed laparoscopically under most circumstances because the repair can be performed with a multilayer closure similar to how the injury would be repaired during open surgery (see Chapter 19). Although significantly more complex, laparoscopic ureteral reimplantation can also be performed with an identical approach as during open repair but requires the skill of an experienced minimally invasive urologic surgeon to do so in a timely fashion. If a surgeon is not comfortable with minimally invasive ureteral reimplantation and an appropriately experienced surgeon is unavailable, we recommend a low threshold to convert to an open approach to avoid the long-term sequelae that can result from unsuccessful minimally invasive repair.

Subcutaneous Emphysema

The accumulation of carbon dioxide in the subcutaneous space during laparoscopic and robotic procedures leads to subcutaneous emphysema. The peritoneum usually prevents such extravasation, but in cases of preperitoneal insufflation, retroperitoneal dissection, or diaphragmatic compromise, carbon dioxide can accumulate outside of the abdomen. The reported incidence of subcutaneous emphysema ranges between 0.3% and 2% for all laparoscopic procedures.

Murdock and colleagues reviewed 968 cases of laparoscopic gynecologic and general surgery and found a 5.5% incidence of hypercarbia, 2.3% incidence of subcutaneous emphysema, and 1.9% incidence of pneumothorax. The predictors for subcutaneous emphysema were peak end-tidal CO\textsubscript{2} above 50 mm Hg (odds ratio, 3.49), operative time longer than 200 minutes (odds ratio, 5.27), and use of six or more surgical ports (odds ratio, 3.06). Notably, body mass index (BMI), cancer, and underlying cardiopulmonary disease were not associated with an increased risk of subcutaneous emphysema. Although others have hypothesized preperitoneal insufflation and extensive retroperitoneal dissection as risk factors for subcutaneous emphysema, this study was underpowered to assess for these relationships. Extrapolation from nephrectomy literature, in which transperitoneal and extraperitoneal approaches are both used, suggests that extraperitoneal insufflation is associated with an increased risk of subcutaneous emphysema.

More recently, Lee and colleagues performed a prospective randomized trial to assess the effect of intraabdominal pressure on subsequent subcutaneous emphysema. Patients undergoing operative gynecologic laparoscopy were randomized to insufflation pressures of 12 mm Hg versus 10 mm Hg. The overall incidence of subcutaneous emphysema was 13.5%, with 19% risk in cases using 12 mm Hg insufflation pressures and 8% risk in cases using 10 mm Hg (P = .02). In addition, these authors found significantly higher rates of subcutaneous emphysema in lower BMI patients and in those with higher peak end-tidal CO\textsubscript{2} measurements. They did not find a significant difference in age, operative time, table tilt angle, or number of ports.

Given the available data, the following factors are recommended to reduce the risk of subcutaneous emphysema:

1. Limit insufflation pressures.
2. Limit the number of port sites whenever feasible.
3. Surgeons should be mindful of trocars slipping out of the peritoneal cavity during the course of a procedure because this allows a track for gas to travel into subcutaneous spaces. If a trocar slips out of the fascia, make every effort to use the same track when reinserting the trocar. Trocars that prevent slipping with either balloon tips or other slip-prevention mechanisms may reduce the risk of this occurring. The trocar with
gas influx attached is of particular concern because direct preperitoneal insufflation can occur quickly at this site.

4. Prolonged operative times should be avoided because this increases the risk of preperitoneal insufflation owing to greater stretching of port-site abdominal wall defects and allows more time for gas to escape.

Subcutaneous emphysema should be suspected if a patient develops crepitus in the lower extremities, abdominal wall, chest, or neck. Perioperative staff are often the first to identify it in the recovery room. Although potentially distressing to the patient, no further intervention is required if the patient is healthy and otherwise stable without evidence of respiratory compromise. It is most often a benign condition, with resolution during the next 24 to 48 hours, and the patient and staff should be reassured accordingly.

Patients with normal cardiopulmonary function easily increase ventilation to breathe off the accumulated carbon dioxide excess seen with subcutaneous emphysema, but those with severe underlying pulmonary disease, such as chronic obstructive pulmonary disease (COPD), are not able to exchange CO₂ properly and can subsequently develop prolonged hypercarbia and respiratory acidosis. This can lead to hypertension, tachycardia, arrhythmias, and altered mental status, in rare cases. If this condition is identified in the operating room, an arterial blood gas measurement should be performed before extubation because prolonged ventilator support may be required until hypercarbia resolves.

In addition to concerns about CO₂ retention, subcutaneous emphysema can, in rare cases, cause physical obstruction of the airway. Prolonged abdominopelvic laparoscopy can lead CO₂ to track into the neck, either by gas extravasation across the diaphragm or via subcutaneous tracking along the chest. This is particularly true of trocars placed in the upper abdomen, such as those placed at the Palmer point in the left upper quadrant. Although there are fascial planes that usually prevent extensive tracking of gas into the lower extremities, such planes do not exist above the diaphragm. Subcutaneous emphysema in the neck can lead to airway compromise, often exacerbated by laryngeal edema in patients in the Trendelenburg position for a prolonged period. In such patients, extended intubation may be necessary. If significant subcutaneous emphysema in the neck is encountered early in a procedure, the surgeon and anesthesiologist must determine whether the procedure should be aborted or altered (i.e., reducing insufflation pressures, checking that trocars have not slipped, considering conversion to laparotomy), so that life-threatening airway obstruction is avoided (Fig. 27.1).

**Gas Embolism**

Gas embolism occurs when carbon dioxide gas is directly injected into the vasculature. This can happen during abdominal entry or at the time of intraoperative vascular injury. The findings of studies in which transthoracic echocardiography was used during minimally invasive procedures suggest that subclinical gas embolism is relatively common. One study of 16 patients undergoing laparoscopic cholecystectomy showed the presence of gas bubbles in the right heart chambers in 11 patients. In a study of 43 laparoscopic radical prostatectomies, 7 (17%) demonstrated gas embolism on transthoracic echocardiogram. In both sets of patients, no cardiovascular changes resulted from the presence of gas emboli.

Clinically significant gas emboli are rare but serious operative complications. A meta-analysis performed by Bonjer and colleagues revealed an incidence of clinically significant gas embolism of 1 in 71,428 closed laparoscopies (0.001%). Cottin and colleagues presented seven cases of clinically significant gas emboli, two of which were fatal. Signs of clinically significant emboli include sudden-onset bradycardia, mydriasis, cyanosis, cardiac arrhythmia, and cardiovascular collapse. There are also rare cases of argon gas embolism with the use of the argon beam coagulator. Reports of these events uniformly include a sudden decrease in end-tidal CO₂ and subsequent cardiovascular collapse. All occurred in the setting of liver bed coagulation with the argon beam coagulator. In addition to venous injection, it is hypothesized that intraabdominal overpressurization with argon gas may cause these emboli.

The surgeon and anesthesiologist should suspect gas embolism in a patient with sudden-onset hypotension, bradycardia, and/or arrhythmia that occurs shortly after carbon dioxide insufflation or after use of the argon beam coagulator. Management is supportive and should include desufflation of the abdomen and cardiopulmonary support with prolonged intubation and blood pressure support as needed.

**Port-Site Hernias**

Port-site herniation is an uncommon but occasionally serious complication after minimally invasive surgery. The risk of hernia formation after minimally invasive surgery is significantly
lower than after laparotomy, with 1-year rates of 1.9% versus 8%, respectively. Herniation may be asymptomatic but can also lead to the need for emergent reoperation in the case of bowel obstruction and strangulation.

A number of risk factors for the development of port-site hernias after minimally invasive surgery have been identified across surgical specialties. These can be divided into patient-related risk factors and technical risk factors. Patient-related risk factors included older age (>60 years), increased BMI (>28 kg/m²), and comorbidities that impair wound healing such as diabetes mellitus, tobacco use, or chronic steroid use. Technical risk factors include closed abdominal entry techniques, larger trocar size, the use of pyramidal trocars for lateral trocar sites, extraumbilical trocar sites, lack of fascial closure, and prolonged operative times (>80 minutes).

Fewer data are available exploring specific risk factors for port-site hernias for gynecologic procedures. Montz and colleagues conducted a survey of AAGL members to identify risk factors and incidence of port-site hernias. Of 4.3 million laparoscopic procedures reported, only 933 hernias were identified, likely suggesting that surgeons underrecognize the incidence of this complication. Of the hernias reported, 86% occurred in 10-mm or larger ports, and 17.9% occurred in spite of fascial closure. Kadar and colleagues reviewed 3650 cases of gynecologic laparoscopy, with a 0.17% overall incidence of incisional hernia identified. All hernias occurred at sites other than the umbilicus, and the risk increased with the use of larger trocars (0% at 5 mm, 0.23% at 10 mm, and 3.1% at 12 mm). As expected, the rate of incisional hernia was higher when the fascial layer was left unclosed, although closure of the fascia was not completely protective.

The site most at risk of herniation is debatable. In the AAGL survey described earlier, 75% of reported hernias occurred at the umbilicus. Preexisting umbilical hernias and enlargement of the umbilical incision to allow for specimen extraction may predispose this site to herniation. In our experience, the umbilicus is the most common location for an asymptomatic hernia to be identified, because hernias in this location are more readily apparent. Extra-umbilical and, in particular, large lateral trocars are also a potential site at high risk for herniation because most operating occurs via instruments placed in lateral ports. Extensive manipulation of these ports throughout a long case may enlarge the fascial incision to more than the initial 10- or 12-mm skin incision without being noticed by the surgeon. Of note, even small trocars (≤5 mm) can result in port-site hernias, so the use of smaller lateral trocars does not completely mitigate risk.

With the changing landscape of minimally invasive techniques, there may be an increase in incisional hernia risk in the future. Marks and colleagues compared rates of incisional hernia between single-site versus multiport laparoscopic cholecystectomy. Although cosmesis scores favored the single-site approach, the rate of herniation was higher with this method versus the multiport approach (8.4% vs 1.2% at 1 year). Benlice and colleagues studied the impact of specimen extraction site on subsequent herniation in laparoscopic colorectal resection. Extraction sites included infraumbilical midline, left or right lower quadrant stoma site, periumbilical midline, Pfannenstiel, and midline converted. The highest rates of herniation were reported at the periumbilical midline (12.6%). All extraction sites had significantly higher rates of herniation when compared with the Pfannenstiel extraction site. With a shift from uncontained power morcellation to contained bag morcellation at the umbilicus, it is likely that the prevalence of periumbilical hernias for patients undergoing minimally invasive surgery for fibroids will increase over time. Surgeons who perform single-site surgery or contained bag morcellation through an extended umbilical incision should be mindful to counsel patients about this added risk and pay particular attention to closure of the fascia at the completion of the procedure.

The most common presenting scenario for an incisional hernia is the patient's report of a mass at or near a port site. For umbilical hernias in particular, the mass can be eccentrically located up to a few centimeters away from the umbilicus. Patients may also have abdominal wall discomfort about this added risk and pay particular attention to closure of the fascia at the completion of the procedure. Patients with symptoms suggestive of postoperative bowel obstruction or peritonitis should have port-site hernia high in the differential diagnosis. If port-site hernia is suspected, abdominal wall ultrasound or computed tomography (CT) can be performed to confirm the diagnosis and determine whether the hernia contains omentum or bowel (Fig. 27.2).

Small (<1 cm), asymptomatic hernias require no intervention but should be monitored for signs of progression. Port-site hernias that are accompanied by discomfort or a bothersome bulge but no obstructive symptoms can be managed non-emergently. Primary suture repair and laparoscopic repair with mesh are both effective options; however, we recommend referral to a surgeon experienced with hernia repair for these procedures because recurrence rates can exceed 10% even in expert hands.
In cases where bowel obstruction is caused by port-site hernia, the approach must be individualized. Incarcerated hernias can lead to strangulation, a potentially life-threatening complication. Laparoscopic reduction of incarcerated bowel can be attempted even in the emergent setting but is often unsuccessful because of poor visualization and/or tight incarceration of the affected segment of bowel. If the incarcerated segment can be carefully reduced without injury, hernia repair can be performed according to surgeon preference either primarily or with a mesh overlay. The bowel must be carefully inspected to ensure viability; delayed perforation can occur if devascularization is unrecognized.

If the incarcerated segment of bowel cannot be reduced laparoscopically or if the surgeon feels uncomfortable with a laparoscopic approach, an incision overlying the hernia site is performed. Careful dissection of the hernia sac should be performed circumferentially until the fascial defect is fully recognized, with particular attention paid to avoiding injury to the bowel, which can be just under the skin in some cases. When hernias develop soon after operation, no hernia sac may be present. If the bowel cannot be reduced at this point, the fascial defect can be extended slightly to allow for reduction. Once the bowel segment is reduced, the bowel must be carefully inspected as outlined earlier. The surgeon should excise the hernia sac and dissect the abdominal wall defect away from devascularized tissue. Again, closure can be performed primarily or with mesh, depending on the size of the defect. If primary closure is attempted, adequate fascial attachments must be identified and closure performed using delayed absorbable suture.

Reducing the rate of incisional hernias is an important goal for any minimally invasive surgeon. Whereas small trocar sites (≤5 mm) appear to be at low risk for hernia formation, larger trocar sites should be closed to prevent the sequel of hernia formation. In obese patients, direct closure of the fascia may be extremely difficult owing to abdominal wall thickness. The use of a blunt conical trocar-cannula system, such as the Carter-Thomason closure device (Cooper Surgical, Trumbull, Connecticut), allows surgeons to place sutures along the lateral edges of the fascia under direct visualization. In most cases, closure is not impeded by adiposity because a threaded cone is used to create the appropriate track in the fascia of the abdominal wall through which the needle suture-passing device is inserted. In limited data, this device may reduce the time of closure. Data regarding hernia risk versus open techniques are lacking, but personal experience suggests a more certain fascial closure with this technique—especially in obese patients.

In summary, minimally invasive techniques reduce but do not eliminate the risk of incisional hernia. Risk factors include increased port size, longer operating times, and increased BMI. Closing larger fascial incisions (10 mm or greater) will decrease, but not eliminate, the risk of herniation, because herniation into the subfascial tissue is also possible. In addition, although rare, herniation through 5-mm ports has also been reported. Herniation is most likely to occur in the weeks after operation and most often manifests with pain and/or bulging at the incision site. Prompt recognition of herniation is imperative to reduce the risk of subsequent bowel strangulation and perforation. Surgical repair of the defect is recommended in most cases.

**Port-Site Metastasis**

Port-site metastasis can occur after any minimally invasive cancer procedure. However, tumor implantation in surgical scars is not unique to minimally invasive surgery. The overall incidence of incisional metastases is reportedly 1% to 2% and is equivalent between laparoscopy and laparotomy.42

Abu-Rustum and colleagues have published one of the largest reviews to date on the incidence of port-site metastases in the gynecologic oncology population.43 In a review of 12 years of laparoscopy for gynecologic malignancies, they found port-site recurrences in 0.97% of cases, with most occurring within 1 year of operation. Of the 1288 patients affected, seven developed laparoscopic port-site metastasis, and seven developed implants at the site of intraperitoneal catheter ports. In the majority of cases, the index operation was performed for advanced or recurrent disease with known carcinomatosis. Under these circumstances, in which the overall risk of recurrence is high, there were no cases of isolated port-site metastasis. As might be expected, the risk of port-site metastasis after operation for organ-confined disease, such as staging for endometrial or cervical cancer, is much lower—0.16% in one large series.44 Although the risk of isolated port-site metastasis is very rare, outcomes appear to be better than for patients with concurrent disease.45

The mechanism by which port-site metastases develop is unknown, but there are several hypotheses: hematogenous spread, direct contamination, effects of pneumoperitoneum, and aerosolization of tumor cells.42 There are small experiments supporting the idea that direct contamination with tumor cells may be responsible for incisional implants.46,47 These studies have confirmed the presence of tumor cells on both laparoscopic instruments and on trocars. In addition, port-site metastases at the incision used for tumor extraction have been shown to be larger than implants at other port sites.48 Similarly, ports used by lead surgeons show more tumor contamination than those used by assistants or by the camera, presumably for the same reason.49 In some cases, tumor could be aerosolized, leading to seeding of tumor at port sites through gas leaking around trocars.50 Available data suggest a relationship between volume of exposed tumor cells and eventual incisional implantation. However, there are also cases of port-site implants in surgeries where no tumor manipulation occurred and no gross abdominal disease was present, speaking against direct wound contamination as a unifying theory to explain port-site metastases.51

Peritoneal insufflation has also been proposed as a cause of port-site metastases. Both human and animal studies have demonstrated lower rates of port-site metastases and intra-peritoneal spread when helium as opposed to carbon dioxide, argon, and nitrogen gases are used for insufflation.52 Similarly, increasing insufflation pressures are associated with greater risk of peritoneal spread and incisional implants in animal models, suggesting that the act of pressurization itself is a risk factor as opposed to the gas type.53 Proposed explanations include tumor cell membrane damage at higher pressures and high solubility of carbon dioxide in native tissues.

Several interventions have been studied in an effort to reduce the risk of port-site metastasis. As described in the aforementioned series, port-site metastases tend to occur in patients with disseminated abdominopelvic disease, so before proceeding...
with a minimally invasive surgical procedure in these patients the surgeon should weigh the benefits of a minimally invasive approach with the risks of incisional contamination. Several studies have looked at various agents for intraperitoneal and port-side lavage, including heparin, taurolidine, 5-fluorouracil, and methotrexate, all of which have shown some promise in reducing peritoneal and incisional implantation. Ramirez and colleagues published the largest summary of factors associated with port-site metastases and recommend the following measures to prevent them:

1. Minimize tissue trauma and instrument exchanges.
2. Rinse trocars with a 5% povidone-iodine solution before insertion and when interchanging.
3. Use protective bags for tumor removal.
4. Deflate the abdomen with trocars in place.
5. Rinse trocar sites with 5% povidone-iodine solution.
6. Close peritoneal defects when using larger trocars.

Port-site metastases often manifest with a palpable mass in the abdominal wall at or near the site of a prior port site. In some cases, an asymptomatic port-site metastasis may be identified on surveillance imaging. In most cases, port-site recurrences develop within 12 months of the antecedent surgical procedure. If port-site metastasis is suspected, CT should be performed to confirm its presence and determine if other sites of recurrence are also present.

There are few data guiding treatment for port-site metastases. Treatment will inevitably vary based on the distribution and burden of disease. Grant and colleagues reported six patients with endometrial cancer who developed isolated port-site recurrences. In all six, local control was achieved at 2 years with excision and radiation to the tumor bed. Similarly, we recommend treating isolated port-site implants with excision followed by radiotherapy (Fig. 27.3). In the case of widespread disease, the presence of port-site metastases does not usually change the treatment plan unless symptoms develop. In patients with subcutaneous metastases that are large, painful, and/or at risk for skin erosion, palliative tumor-directed radiation may prevent progression to skin ulceration and decrease local symptoms.

**Vaginal Evisceration**

Vaginal cuff dehiscence is a rare but potentially devastating complication of minimally invasive hysterectomy. Bowel prolapse with subsequent ischemia, perforation, and peritonitis can be deadly. The incidence of vaginal cuff dehiscence in patients undergoing minimally invasive hysterectomy is higher than in open cases, with dehiscence rates of 0.64% versus 0.2%, respectively. Uccella and colleagues reviewed 665 consecutive minimally invasive hysterectomies at their institution and reviewed data from 57 similar studies including an additional 13,000 patients. In this meta-analysis, the pooled incidence of vaginal cuff dehiscence was 0.64% with laparoscopic closure of the cuff, 0.18% with vaginal closure, and 1.64% with robotic closure.

As these results demonstrate, closure of the cuff vaginally is associated with a significantly lower rate of cuff dehiscence when compared with laparoscopic closures. In fact, in a study by the same group, vaginal closure after laparoscopic hysterectomy and abdominal hysterectomy had similar dehiscence rates (0.24% and 0.21%, respectively). There are several hypotheses to explain this phenomenon. The magnified view of the laparoscope distorts the operative field and may lead the surgeon to take inappropriately small segments of tissue when suturing. In addition, the knots tied with the surgeon’s hands during vaginal closure are likely more reliable than those tied laparoscopically, where the tension applied to the suture is more variable. It is also hypothesized that the use of electrocautery at the time of colpotomy leads to surrounding tissue damage and subsequently impaired healing in minimally invasive cases compared with abdominal or vaginal approaches. There are few data comparing outcomes of colpotomy performed with versus without electrocautery. In one study in which the use of 60-W versus 50-W monopolar energy was compared, the there was no difference in vaginal cuff dehiscence rates. In a review of 2300 hysterectomies by Fuchs Weizman and colleagues, the colpotomy method (cold, bipolar, monopolar, and harmonic) was not associated with dehiscence risk. Similarly, they found no difference between suture type and closure type (i.e., interrupted versus continuous).
Robotic closure does appear to be associated with significantly higher rates of dehiscence when compared with other methods, although it remains unclear why this would be the case. It is possible that tension applied by robotic arms is less reliable than that applied by the surgeon's hands or by laparoscopic instruments. Robotic techniques are also the newest of the three methods, so rates of dehiscence may decrease as the technology becomes more widely adopted and as surgeons gain more experience with this modality. In fact, Hur and colleagues demonstrated that vaginal cuff dehiscence rates fell during an 8-year period, suggesting that increased surgeon experience is protective.

In addition to technique, there have been several other risk factors for vaginal dehiscence identified. Hysterectomy for malignancy is associated with higher rates of dehiscence. This can be attributed to several factors, including the need for subsequent radiation or chemotherapy in many patients. Other identified risk factors include conditions that predispose patients to poor wound healing (e.g., diabetes, cigarette smoking, malnutrition, and conditions requiring long-term steroid use), increasing age and postmenopausal status, and conditions that increase intraabdominal pressure, such as obesity, chronic lung disease, and constipation. It is also likely that patients who experience postoperative complications such as vaginal cuff cellulitis, hematoma, or urinary tract injury are at increased risk of dehiscence. All of these risk factors likely put patients with gynecologic malignancies at increased risk of cuff dehiscence.

Sexual intercourse is a common inciting event causing vaginal cuff dehiscence. In a review of the literature performed by Agdi and colleagues, sexual activity was the most common trigger of dehiscence, although in other reviews most vaginal cuff separations were spontaneous. In this study, the average interval between operation and resumption of sexual activity in patients with dehiscence was 7 weeks, suggesting that perhaps a longer period of pelvic rest may be indicated in these patients. To our knowledge, there are no studies specifically comparing different durations of pelvic rest. We recommend 6 to 8 weeks of pelvic rest, with this duration extended in patients with the aforementioned risk factors or when it appears at the pelvic examination 4 to 6 weeks after operation that the cuff is healing more slowly than normal.

Vaginal evisceration should be suspected in patients with sudden-onset vaginal fullness, abdominal pain, vaginal bleeding, and/or discharge. In many cases, evisceration is preceded by an inciting event such as intercourse or increased intraabdominal pressure (e.g., coughing or defecating), although it can occur spontaneously as well. Ileum is the most common structure to prolapse, but cases of prolapsed colon and epiploica have also been reported. A careful abdominal, pelvic, and rectal examination should be performed if dehiscence is suspected. Peritoneal signs and signs of sepsis should raise concern for bowel evisceration and rupture.

Management of vaginal cuff dehiscence is individualized. Surgeons should have a low threshold to perform an examination with the patient under anesthesia if cuff dehiscence is suspected, especially if visualization is suboptimal in the office. If a careful physical examination reveals no evidence of evisceration, the vaginal cuff defect can be closed vaginally. If the defect is small, expectant management is also reasonable if the patient is otherwise healthy and reliable. In either case, broad-spectrum antibiotics should be started owing to the risk of peritonitis from ascending vaginal flora.

If evisceration is identified, urgent operative management is necessary. Preoperative imaging is recommended if the patient is hemodynamically stable. A CT scan can help identify a retained object, abscess, hematoma, or urinary tract injury that would help guide the surgeon toward a vaginal or abdominal approach. When evisceration is identified, the vagina and bowel should be irrigated with warm saline and the bowel carefully inspected for injury. If the bowel is easily reducible, it may be returned to the abdomen with subsequent packing of the vagina and Trendelenburg positioning, if possible. The decision to close the defect vaginally or abdominally should also be individualized depending on the hemodynamic status of the patient and concern for bowel injury or associated intraabdominal process (e.g., hematoma, urinary tract injury). With vaginal closure, examination of the bowel is limited, and there is a risk of unidentified injury, although it spares the patient a second abdominal operation. If an abdominal approach is taken, the entirety of the small bowel and its mesentery should be examined for injury. If a bowel injury is identified, that portion of the bowel should be removed and peritoneal irrigation performed. The edges of the vaginal defect should be debrided until the tissue appears healthy and then subsequently closed with interrupted or figure-of-eight absorbable sutures. Placement of abdominal drains may be appropriate if an abscess is present.

**Conclusion**

Not all complications from minimally invasive surgery can be prevented. Careful attention to surgical technique can mitigate risk but not fully prevent all problems that can arise. An awareness of possible complications and an understanding of how to manage them can minimize the risk to patients and prevent serious morbidity and mortality in most circumstances.

**Key Points**

- Open abdominal entry using the Hasson technique may reduce the risk of vascular but not bowel injuries.
- In general, it is recommended that surgeons use the abdominal entry method with which they have the most comfort, recognizing that all techniques carry risk of injury.
- To reduce the risk of injury to the bowel and urologic tract, surgeons should be mindful of the maximal lateral thermal spread of all energy devices used.
- Routine cystoscopy during laparoscopic hysterectomy may reduce the risk of unrecognized bladder injury but not all thermal injuries to the ureter or bladder.
- Subcutaneous emphysema can be minimized by reducing insufflation pressures, decreasing the operative time and number of port sites wherever feasible, and minimizing trocar slippage during minimally invasive surgery.
- Port-site hernia risk increases with trocar size. Trocar sites 10 mm or more in diameter should be closed to prevent hernia formation.
- Port-site metastases occur infrequently after oncologic laparoscopy. Risk can be minimized by adhering to a number of guidelines outlined in the chapter.
- Vaginal evisceration should be suspected in patients with sudden-onset vaginal fullness, abdominal pain, vaginal bleeding, and/or discharge.
Chapter 27

Complications of Minimally Invasive Surgery

Although management of vaginal cuff dehiscence is individualized, surgeons should have a low threshold to perform an examination with the patient under anesthesia if cuff dehiscence is suspected.

References


