RECONSTRUCTIVE AND REPRODUCTIVE SURGERY IN GYNECOLOGY

SECOND EDITION

VOLUME 1: FUNDAMENTALS AND CONDITIONS

EDITED BY

MALCOLM G. MUNRO • VICTOR GOMEL

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Reconstructive and Reproductive Surgery in Gynecology

Second Edition

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Introduction

> Performed for other than trauma, congenital defects and cosmetics, "surgery" represents the failure of medicine; failure of elucidating the etiology of the disease and developing specific and effective preventive and therapeutic measures.
>
> **Victor Gomel**

A CHANGING DEMOGRAPHIC

During the last four decades, we have witnessed rapid and significant innovations in various scientific and technological fields that have changed the practice of medicine including our own specialty. In parallel fashion, there have been important demographic and social changes that affect both the world in which we live and the nature of our medical practice.

In the short span of 30 years from 1987 to 2017, the world population has increased from 5 billion to over 7 billion, a growth rate that shows no signs of relenting and a circumstance that challenges both the resources and the environmental conditions of our planet and its inhabitants. This population growth occurred despite the simultaneous decline in the birth rate of industrialized nations. Together with the continuous prolongation of mean life expectancy, this reduced population growth is significantly increasing both the absolute and relative numbers of elderly individuals in the developed world, a dramatic change with important social, economic, and political consequences.

The environmental "new normal" will be characterized by a population of women who will live increasingly longer, prolong their stay in the workforce, and likely continue to delay childbearing to the later reproductive years, and even beyond. These trends, in themselves, have important repercussions for medical practice in general, and our specialty in particular. Women will require medical care during a much longer postmenopausal life span. They will increasingly seek anti-aging treatment, more often undergo cosmetic surgery, and more frequently require reconstructive procedures for various conditions such as stress incontinence and genital prolapse. Indeed, there are already many gynecologists who include cosmetic surgery as part of their practice.

Women who enter and stay in workforce typically delay childbearing—a circumstance that contributes to trends evident today. The total fertility rate (estimated number of births over a woman's lifetime) in the United States is about 1.84 births per 1,000 women, which is below the rate of 2.1 births per 1,000 women necessary for a generation to exactly replace itself. The average age of the proportion of U.S. women who had their first child when they were over 30 years of age increased from 5% in 1975 to 22% in 1995, reaching 30.3% by 2015.[1]

Delay in childbearing will increase demand for assisted reproductive technology (ART) services. Already, over 60% of those using ART are 35 years of age and older. ART services have become industrialized; the number of reporting clinics in the United States has increased from 267 in 1995 to 464 in 2015. Similarly, the number of annual cycles performed has increased from 34,000 in 1995 to 134,260 in 2005 to 231,936 in 2015,[2,3] an increasing trend that will likely continue, as will the attendant-associated costs. The demand has already resulted in an annual economic burden of about $2.5 billion in the United States and more than €5 billion euros in the European Union, where more than 500,000 cycles are performed annually. There will also be an increasing desire for techniques designed to preserve fertility; embryo, oocyte, ovarian tissue, and stem cell banking is already in use. These techniques, and others, will undoubtedly be improved and expanded to respond to the increasing demand.

EVOLVING TRENDS IN GYNECOLOGY

Gynecologic practice, like medicine as a whole, continues to evolve. The gynecological surgeon of the twenty-first century is typically different from many of those of other surgical specialties. Unlike most specialists, gynecologists must function as both the "internist" and the "surgeon" for women with reproductive disorders. Consequently, it is important that a sound understanding of physiology, anatomy, and the pathogenesis of diseases and disorders be combined with the expanding set of requisite skills at clinical assessment necessary to formulate a complete set of management options for consideration by the patient. Knowledge of the role for expectant management and the entire spectrum of appropriate medical, procedural, and surgical interventions is important.

The technical aspects of gynecological practice have dramatically changed as a result of progress in many scientific fields: physics, immunology, biochemistry, DNA technology, microprocessor technology, mechanical engineering, medical imaging, cell and molecular biology, and others.

Especially important to contemporary gynecological practice is progress in imaging technologies, including ultrasonography, computed tomography (CT), positron emission tomography (PET) scanning, and magnetic resonance imaging (MRI) that have collectively reduced the need for surgery-based diagnosis. In addition, interventions directed by imaging ("interventional radiology") include targeted biopsy and treatment of lesions such as adenomyosis or leiomyomas by vascular embolization, radiofrequency and cryogenic probes, and trackless ablation with focused ultrasound have collectively provided options to traditional surgery that have the potential to reduce treatment related morbidity.[4,5] Uterine artery embolization has proven to be a good alternative to surgery in selected instances of acute hemorrhage and symptomatic uterine leiomyomas.[4]

Scientific developments and technical inventions are permitting treatment of many conditions medically, avoiding procedures including traditional surgery altogether. Already, innovations, such as progesterone receptor modulators for leiomyomas, various progestins and GnRH agonists and antagonists for endometriosis, and intrauterine progestin releasing systems for a number of causes of abnormal uterine bleeding, are contributing to the decline in hysterectomy rates. Early diagnosis of ectopic pregnancy, combined with the use of systemic methotrexate, has resulted in a dramatic reduction in the surgical management of this condition. Ultrasound imaging allows the identification of adnexal cysts that are known to be benign, therefore obviating the need for surgical removal for diagnosis. Recognition of the role of the human papilloma virus in the pathogenesis of cervical neoplasia, including cervical cancer, has allowed for the development of vaccines designed to prevent this ubiquitous disorder.[6,7]

The face of gynecology has been dramatically changed by the gender of applicants to obstetrics and gynecology training programs in the developed world, the majority now being women. Once in practice, they tend to be much more rational in their working habits and work fewer hours per week than their male counterparts, and they appear to retire earlier.[8–10] These changes may have significant impact on the availability of obstetrical and gynecological specialists.

TECHNOLOGY AND THE GYNECOLOGIC SURGEON

The transition of gynecological surgical practice, from one largely based on laparotomy to an approach largely based on hysteroscopic and laparoscopically directed procedures, has been both dramatic and uneven. It is apparent that specialty training programs are inconsistent, and, as a result, not all women are able to access the entire spectrum of options. Furthermore, the development of laparoscopic technique has eroded training in vaginal surgery, the original minimally invasive technique for hysterectomy in particular.

Technical innovations had a very important role in each of the steps of the development of endoscopy, including the initiation and acceptance of operative procedures, and in making it possible for more complex operations to be performed with greater efficiency and safety. These technical developments included more sophisticated insufflators, endoscopes with improved optics, refined energy-based surgical instruments, and the development of television imaging systems adapted for medical use.

Perhaps the most important technological advance facilitating the widespread use of endoscopic surgery was the charge-coupled device (CCD), the chip that revolutionized imaging by allowing television cameras to be reduced to fingernail dimensions, and for which the inventors, W S Boyle and G E Smith, received the 2009 Nobel prize in physics.[11] When attached to an endoscope, these miniaturized cameras, coupled with television monitors, quickly became an integral part of surgical imaging systems that have quickly evolved to provide high definition or higher resolution of the surgical field.

The ability to operate by viewing the operative field on TV monitors enabled the surgeon, surgical assistant, and operating room personnel to work as an efficient team. These innovations, introduced in the early 1980s, permitted the rapid evolution of minimal access surgery. Indeed, even the most complex gynecological procedures are now being routinely and successfully performed by laparoscopy.

While hysteroscopic procedures have been documented in the medical literature since 1869,[12] worldwide adoption has been uneven, despite the obvious advantages of incision-less surgery. Until the 1970s, hysteroscopy was portrayed by many as "a technique looking for an indication" and was typically confined to a diagnostic role, practiced by only a relative handful of surgeons. However, in the last part of the twentieth century, innovation took hold and the hysteroscope and its cousin, the uterine resectoscope, became instruments of radical change in the surgical approach to intrauterine pathology. Many procedures that previously required a laparotomy and a hysterotomy to access the uterine cavity could be performed absent any abdominal incision (e.g., lysis of severe uterine synechiae, metroplasty for septate uterus, and excision of symptomatic intrauterine fibroids).[13–15] Not only was there an improved cosmetic result, with low morbidity and reduced cost, but also most procedures became amenable to performance in an office environment under local anesthesia.[16–18] The evolution of imaging procedures, such as three-dimensional vaginal ultrasound and MRI, has allowed the hysteroscopic surgeon to forego diagnostic laparoscopy to evaluate Müllerian anomalies, while intraoperative transvaginal ultrasound allows for the safe performance of difficult dissections of intrauterine adhesions and leiomyomas that involve the myometrium.[19] Intrauterine surgery has evolved even further with the development of endometrial ablation devices for the treatment of selected causes of chronic abnormal uterine bleeding,[20] and intrauterine ultrasound directed radiofrequency electrosurgical ablation for deep FIGO Type 2 and Type 3 leiomyomas.[21]

THE MEDICAL DEVICE INDUSTRY: FRIEND OR FOE?

The rapid technological development of endoscopic and image-guided surgery has required the investment and innovation possible only with the support and leadership of the medical device industry. Indeed, identification of clinical requirements and design concepts as well as the need for the performance of clinical trials to evaluate efficacy and safety requires that industry and gynecological surgeons work together to bring effective products to market. Once new surgical devices become available, it is necessary to train clinicians and support staff in their appropriate, safe, and effective use in patients. This process frequently requires the presence of company representatives in the clinical environment. While absolutely necessary, this partnership between the medical and industrial communities is a source of controversy, as there exist opportunities for corporate influence over medical decision-making.[22–24]

Indeed, regulatory agencies in the United States and elsewhere now require public disclosures of the nature and extent of relationships of clinicians and hospitals with the industry. While this transparency is generally considered to be appropriate and healthy, unintended consequences include a reluctance of institutions, including universities and hospitals, to have their names, or those of their faculty, appear on these public disclosures. Consequently, these measures can threaten the integrity of the crucible of creative cooperation that exists between the industry and the medical profession in a way that is detrimental to both patients and society at large. Moving forward, it will be important to establish a climate of transparency that does not undermine the innovation necessary to advance medical care.

It is also important for the medical profession to use evidence to counter the notion, where appropriate, that new drugs or devices necessarily result in better outcomes for patients. Care must be taken to ensure that new drugs with higher cost do not replace established agents that are less expensive yet highly efficacious. And it is important that costly, single-use devices are not used when reusable and less expensive systems provide the same outcome quality.

The same applies to capital equipment, particularly exemplified by the Da Vinci® system, a complex and expensive device designed to assist the performance of laparoscopic surgery. It may facilitate the provision of laparoscopic instead of laparotomic procedures by less trained individuals, and it allows the surgeon to carry out the procedure remote from the surgical field without even scrubbing—quite an accomplishment. However, available evidence suggests that the use of such equipment, at least in its current manifestation, only adds to the cost of laparoscopic procedures without improving any measurable clinical outcome. A previously published large U.S. study demonstrated that da Vinci–assisted laparoscopic surgery added $2,189 (95% CI $2,030 to $2,349) to the cost of each case,[25] perhaps reduced to $1,617 if only benign cases were included,[26] and a Finnish-based systematic review and meta-analysis showed that da Vinci–assisted laparoscopic hysterectomy increased costs by 1.5 to 3 times without improvement in any measurable clinical outcome.[27] Avoidance of being captured by such technology will be a continuing goal that is made more difficult by the need to simultaneously foster its development. For example, when microprocessor-based systems like da Vinci can create "virtual ports" through a single and small umbilical incision and deliver the surgical result with some combination of reduced risk, maintained efficacy, and lower cost, the technology will have provided us with true value.

GYNECOLOGICAL SURGICAL TRAINING IN THE TWENTY-FIRST CENTURY

While these advances contribute to an overall reduction in the number of gynecologic surgical procedures per population, the complexity of those surgical procedures that are performed is increasing.[28] Indeed, there is already evidence that complication rates associated with hysterectomy are on the rise.[29,30]

This shrinking overall pool of surgical interventions, combined with the increasing variety of procedures, challenges gynecologic surgeons to acquire a wider spectrum of competencies. Consequently, there is a greater, not lesser, need for surgeons with optimal training and skill and the ability to perform safe, effective, and minimally invasive gynecological procedures by the most appropriate route, be it hysteroscopic, vaginal, laparoscopic, or via laparotomy. This situation confronts contemporary gynecological surgical educators with a related challenge: finding ways to foster the development of competency despite this diluted procedural environment. The problem is amplified as the training period for specialization has been significantly shortened by reducing the working hours of the trainees, the residents, or the registrars, including the frequency of nights and weekends "on call."

One suggested solution to the issues described above has been the use of surgical simulation, where psychomotor skills are learned and honed in an inanimate environment.[31] Inherent in the concept of surgical simulation is the notion that training for many surgical skills and techniques can be more effectively and safely accomplished without incurring the costs associated with inefficiency and avoidable complications. Surgical efficiency is increasingly under scrutiny, as the cost of surgical time is rising disproportionate to inflation. Operating room charges or costs are estimated by the minute and, in the United States at least, can exceed $100 for 60 seconds of surgery. Safety is a major issue as well. Indeed, the Institute of Medicine (IOM) has charged the healthcare industry to include simulation in surgical training and credentialing as a critical component of an overall strategy to reduce surgical risks.[32]

Duration of specialty training is another approach that could result in surgeons who are better prepared to provide the spectrum of minimally invasive approaches. While training programs in the United States are only 4 years long, those in other developed countries are frequently 5 to 7 years in duration, or, in some, even based on competency, with no established program duration. Even in these environments there is frequently an inadequate case load for surgical training, as the specialty includes training in obstetrics and, at least in the United States, primary care—a circumstance that further dilutes exposure to surgical interventions.

Case dilution, a particular problem in the United States, is further enhanced with the increasing numbers of subspecialty trainees competing for the limited hospital and patient resources. These formally defined subspecialty training programs began in the second half of the last century with official recognition of maternal fetal medicine, gynecologic oncology, and reproductive endocrinology and infertility as official subspecialties. More recently, urogynecology, in the United States called "female pelvic medicine and reconstructive surgery," has been accepted into the fold. But these subspecialties do not encompass the large group of surgical procedures for benign disease that involve the uterus and adnexa, and the increasing trend of reproductive endocrinologists to eschew infertility surgery can add to the case mix for the gynecologic surgeon.

Perhaps the most logical approach to improving the training of gynecologic surgeons would be the addition of a new subspecialty: post-residency training programs in minimally invasive gynecologic surgery. Proliferating in a number of countries, including Australia, Canada, the United States, and others, these fellowships remain inconsistent, with variable training in the spectrum of minimally invasive approaches including vaginal, hysteroscopic, laparoscopic, and image-guided procedures. Many such programs tend to favor one approach over another, and the production of surgeons with the expert ability to offer all of the approaches remains limited. Obviously, for such programs to produce a consistent surgeon "product," it will be necessary to apply rigid standards on the spectrum of cases required for certification.

The addition of sub-specialization to the "core" residency training programs in obstetrics and gynecology clearly prolongs the duration of training. Some have suggested that a solution to this problem would be the separation of obstetrics and gynecology, a process that, to an extent, is already occurring as those who specialize in maternal fetal medicine rarely, if ever, practice gynecology.

We contend that whatever the "core" training, the gynecologist offering care to women who have gynecological disorders that may require medical, procedural, or combination therapy should possess the spectrum of diagnostic and therapeutic skills to provide the most appropriate options in a safe and effective fashion. Being "comfortable with" only some approaches means that the individual may be uncomfortable with or unable to provide the type of care most appropriate for a given patient. If access is limited or if the surgeon recognizes that he or she is unable to provide some of the options, the patient should be so counseled, and, if necessary, attempts should be made to access that needed resources elsewhere.

AND SO, THIS BOOK

This extensively revised and rewritten textbook is designed to educate current and future gynecologic surgeons on the pathogenesis, investigation, and medical and procedural management of disorders affecting the female reproductive tract. Whereas the focus is on reconstructive vaginal, hysteroscopic, laparoscopic, and laparotomic surgery designed to preserve or enhance fertility, others such as hysterectomy and endometrial ablation are included.

Section I, "Fundamentals," includes chapters designed to foster a sound understanding of pelvic anatomy, reproductive physiology, pelvic imaging, and core components of the various surgical approaches as well as the prevention and management of related adverse events. Section II, "Gynecologic Disorders," covers the pathogenesis, investigation, and medical management of the disorders likely encountered that have a potential surgical solution. It is designed to ensure that the role of procedures or surgery is placed in proper perspective. The pathway from a symptom or a finding to the appropriate management options is critically important and is the focus of chapters that comprise Section III. Section IV presents the spectrum of surgical procedures using text, graphics, and video clips designed to demonstrate examples of surgical technique. Each chapter is introduced with "Key Points." Referencing is extensive but confined to the electronic version of the text.

We hope that these multimedia volumes, approaching gynecological disorders from multiple perspectives (pathogenesis, presenting symptoms or findings, and medical and procedural management), will be useful tools and aid the education of contemporary surgeons of the female reproductive tract. However, it should be remembered that since science is not static, the gynecological surgeon should continuously and critically scrutinize the newly revealed evidence, with the goal of providing the best options for care delivered in the safest and most effective fashion possible.

> Change alone is eternal, perpetual, immortal.
>
> **Arthur Schopenhauer**
> *1788–1860*

REFERENCES

1. Martin JA, Hamilton BE, Osterman MJK, Driscoll AK, Mathews TJ. Births: Final Data for 2015. Prevention CfDCa; 2017 January 5, 2017.
2. Centers for Disease Control and Prevention ASfRM, Society for Assisted Reproductive Technology. 2014 Assisted Reproductive Technology National Summary Report. Atlanta, GA: US Dept of Health and Human Services, Health DoR; 2016 October 2016.
3. Centers for Disease Control and Prevention ASfRM, Society for Assisted Reproductive Technology. 2015 Assisted Reproductive Technology National Summary Report. Atlanta, GA: US Dept of Health and Human Services, Health DoR; 2017 October 2017.
4. Goodwin SC, Bradley LD, Lipman JC, Stewart EA, Nosher JL, Sterling KM, et al. Uterine artery embolization versus myomectomy: a multicenter comparative study. *Fertil Steril*. 2006;85(1):14-21.
5. Rabinovici J, Stewart EA. New interventional techniques for adenomyosis. *Best Pract Res Clin Obstet Gynaecol*. 2006;20(4):617-36.
6. Villa LL, Costa RL, Petta CA, Andrade RP, Paavonen J, Iversen OE, et al. High sustained efficacy of a prophylactic quadrivalent human papillomavirus types 6/11/16/18 L1 virus-like particle vaccine through 5 years of follow-up. *Br J Cancer*. 2006;95(11):1459-66.
7. Nicol AF, de Andrade CV, Russomano FB, Rodrigues LS, Oliveira NS, Provance DW, Jr., et al. HPV vaccines: Their pathology-based discovery, benefits, and adverse effects. *Ann Diagn Pathol*. 2015;19(6):418-22.

8. Rayburn WF, Gant NF, Gilstrap LC, Elwell EC, Williams SB. Pursuit of accredited subspecialties by graduating residents in obstetrics and gynecology, 2000-2012. *Obstet Gynecol*. 2012; 120(3):619-25.
9. Barnhart KT, Nakajima ST, Puscheck E, Price TM, Baker VL, Segars J. Practice patterns, satisfaction, and demographics of reproductive endocrinologists: results of the 2014 Society for Reproductive Endocrinology and Infertility Workforce Survey. *Fertil Steril*. 2016;105(5):1281-6.
10. Rayburn WF, Tracy EE. Changes in the Practice of Obstetrics and Gynecology. *Obstet Gynecol Surv*. 2016;71(1):43-50.
11. Foundation ANM. Nobelprize.org: Nobel Media AG; Available from: https://www.nobelprize.org/nobel_prizes/physics/laureates/2009/.
12. Pantaleone DC. On endoscopic examination of the cavity of the womb. Medical Press and Circular London. 1869;8:26-7.
13. Neuwirth RS, Amin HK. Excision of submucus fibroids with hysteroscopic control. *Am J Obstet Gynecol*. 1976;126(1):95-9.
14. Chervenak FA, Neuwirth RS. Hysteroscopic resection of the uterine septum. *Am J Obstet Gynecol*. 1981;141(3):351-3.
15. Neuwirth RS. Hysteroscopic management of symptomatic submucous fibroids. *Obstet Gynecol*. 1983;62(4):509-11.
16. Porreca MR, Pansini N, Bettocchi S, Loverro G, Selvaggi L. Hysteroscopic Polypectomy in the Office without Anesthesia. *J Am Assoc Gynecol Laparosc*. 1996;3(4, Supplement):S40.
17. Bettocchi S, Ceci O, Nappi L, Di Venere R, Masciopinto V, Pansini V, et al. Operative office hysteroscopy without anesthesia: analysis of 4863 cases performed with mechanical instruments. *J Am Assoc Gynecol Laparosc*. 2004;11(1):59-61.
18. Keyhan S, Munro MG. Office diagnostic and operative hysteroscopy using local anesthesia only: an analysis of patient reported pain and other procedural outcomes. *J Minim Invasive Gynecol*. 2014;21(5):791-8.
19. Korkmazer E, Tekin B, Solak N. Ultrasound guidance during hysteroscopic myomectomy in G1 and G2 Submucous Myomas: for a safer one step surgery. *Eur J Obstet Gynecol Reprod Biol*. 2016;203:108-11.
20. Munro MG. Endometrial ablation. *Best Pract Res Clin Obstet Gynaecol*. 2018;46:120-39.
21. Brolmann H, Bongers M, Garza-Leal JG, Gupta J, Veersema S, Quartero R, et al. The FAST-EU trial: 12-month clinical outcomes of women after intrauterine sonography-guided transcervical radiofrequency ablation of uterine fibroids. *Gynecol Surg*. 2016;13:27-35.
22. Camp MW, Gross AE, McKneally MF. Patient views on financial relationships between surgeons and surgical device manufacturers. *Can J Surg*. 2015;58(5):323-9.
23. Bendavid R. Patient views on financial relationships between surgeons and surgical device manufacturers. *Can J Surg*. 2015;58(6):E7-8.
24. O'Connor B, Pollner F, Fugh-Berman A. Salespeople in the surgical suite: relationships between surgeons and medical device representatives. *PLoS One*. 2016;11(8):e0158510.
25. Wright JD, Ananth CV, Lewin SN, Burke WM, Lu YS, Neugut AI, et al. Robotically assisted vs laparoscopic hysterectomy among women with benign gynecologic disease. *JAMA*. 2013;309(7):689-98.
26. Wright JD, Ananth CV, Tergas AI, Herzog TJ, Burke WM, Lewin SN, et al. An economic analysis of robotically assisted hysterectomy. *Obstet Gynecol*. 2014;123(5):1038-48.
27. Tapper AM, Hannola M, Zeitlin R, Isojarvi J, Sintonen H, Ikonen TS. A systematic review and cost analysis of robot-assisted hysterectomy in malignant and benign conditions. *Eur J Obstet Gynecol Reprod Biol*. 2014;177:1-10.
28. Fingar KR, Stocks C, Weiss AJ, Steiner CA. Most frequent operating room procedures performed in U.S. hospitals, 2003-2012: statistical brief #186. Healthcare Cost and Utilization Project (HCUP) Statistical Briefs. Rockville (MD)2006.
29. Hilton P, Cromwell DA. The risk of vesicovaginal and urethrovaginal fistula after hysterectomy performed in the English National Health Service--a retrospective cohort study examining patterns of care between 2000 and 2008. *BJOG*. 2012;119(12):1447-54.
30. Kiran A, Hilton P, Cromwell DA. The risk of ureteric injury associated with hysterectomy: a 10-year retrospective cohort study. *BJOG*. 2016;123(7):1184-91.
31. Munro MG. Surgical simulation: where have we come from? Where are we now? Where are we going? *J Minim Invasive Gynecol*. 2012;19(3):272-83.
32. US Institute of Medicine CoQHCiNA. Crossing the quality chasm: a new health system for the 21st century. Washington, D.C.; 2001.

Anatomy and surgical dissection of the female pelvis

For the gynecologic surgeon

1

ANDREW I. BRILL, ROBERT M. ROGERS, JR., and VICTOR GOMEL

Key points

- Surgical outcome is closely linked to techniques of tissue dissection coupled with a working knowledge of surgical anatomy.
- The dynamics of surgical teamwork are inseparably related to the technical and cognitive aspects of pelvic surgery.
- Providing surgical dissection in spaces without visceral or vascular structures, the pelvic sidewall structures are found in three layers that are separated by two avascular dissection planes.
- Given that the pelvic brim is usually spared from chronic inflammatory conditions of the pelvis such as endometriosis, it is typically the best anatomical area to begin a retroperitoneal sidewall dissection.
- When the pelvic brim is anatomically obliterated, the round ligament can be used to reach the uterine artery by following the obliterated umbilical artery to the base of the internal iliac artery where the uterine artery is the medial branch.
- The ureter is only 2 to 3 cm superior and medial to the ischial spine where it passes just posterior to the uterine artery and then continues across the pubocervical fascia to enter the bladder at the junction of the middle and upper third of the vagina.
- The anatomical support of the uterus is provided by the pubocervical fascia anteriorly, cardinal and uterosacral ligaments posteriorly and apically.
- The sensory and sympathetic nerve supply of the female pelvic organs are found in the inferior hypogastric nerve, whereas the parasympathetics emanate from the pelvic splanchnic nerves from the S2 to S4 roots of the sacral plexus.

INTRODUCTION

Apart from anatomy relevant to surgical dissection in specific areas of the female pelvis, the bridge between knowledge of pelvic anatomy and efficient surgical practice requires mastery of several techniques of surgical dissection. This chapter describes three fundamental areas that are essential to the successful surgeon: key techniques of tissue dissection, the dynamics of surgical teamwork, and a working knowledge of surgical anatomy. Proper tissue dissection frequently requires restitution to normal anatomy by lysis of adhesions and by systematic exploration within various areas of the pelvic retroperitoneum. As collaboration is essential to optimally perform successful surgery, teamwork relies on leadership skills to coordinate the roles of all team members to achieve a "synergy of purpose." In addition to key visceral and structural pelvic anatomy, the pre-sacral space, the pelvic brim, the pelvic sidewall, the base of the broad ligament/cardinal ligament, the paravesical space, the retropubic space, the vesicovaginal space, the pararectal space, and the rectovaginal space will be reviewed.

SURGICAL DISSECTION: THEORY AND DISCUSSION OF TECHNIQUES

The purpose of deliberate surgical dissection is to do no harm to the patient, while safeguarding vital anatomic structures and blood vessels. The goal is to perform the dissection in order to avoid injuring the viscera, ureter, and somatic nerves and to limit blood loss. Most surgeons read, study, and strive to master knowledge of surgical anatomy. However, they assume that skilled dissection techniques will soon follow. Not so! Tissue dissection techniques must be learned, understood, and practiced as rigorously and consistently as any surgical skill, such as laparoscopic suturing or use of new surgical instrumentation. Correct knowledge and focused practice gradually result in safe and efficient dissection techniques. Importantly, the surgeon must acknowledge that he/she cannot operate alone and must have assistants to aid her/him in the surgical procedure. The surgeon is only one part of a surgical TEAM that can accomplish any surgery when working in an environment of experience and mutual respect.

The purpose of surgical dissection is to thin out adhesions, scar tissue, and/or visceral connective tissues in order to visualize the anatomic structures contained nearby or therein. In the pelvic cavity itself, adhesions can be fine and filmy, to denser and shorter, and then to very thick, nodular, and hard. Some cases require minor surgical lysis. In other more challenging cases, the denser and harder scarring can result in the dangers of surgical dissections in a "frozen pelvis." Adhesions can and do adhere from the female organs to the bladder peritoneum, to the serosa of the colon and intestines, and to the parietal peritoneum of the cul-de-sac and sidewall. In the retroperitoneal areas and spaces, both normal visceral connective tissues and scar tissue can coexist to challenge the dissection skills of the surgeon. Dissections in both the pelvic cavity and the retroperitoneum utilize the same techniques.

In the retroperitoneum, the visceral connective tissues serve two important purposes.[1] One is to envelope and mechanically support the visceral blood vessels, nerves, and lymph nodes and channels that service the viscera. The other is to follow these visceral structures to their viscera for the purposes of mechanical suspension of these organs, such as the bladder, cervix and vagina, and the rectum. The visceral connective tissues anchor the pelvic viscera to the parietal fascia of the back wall and sidewall of the pelvis. For example, the cardinal ligament/uterosacral ligament complex of visceral connective tissue envelopes the internal iliac artery and vein and is led to the paracervical ring by the uterine artery. The cardinal ligaments and uterosacral ligaments are anchored to the back wall and sidewall of the pelvis. They suspend the cervix and upper vagina over the tendinous levator plate. The levator plate is the dynamic backstop that functions to help prevent uterine and vaginal prolapse during episodes of increased intrapelvic (Valsalva) pressure.

The first and most important principle of surgical dissection is exposure of anatomic structures. Ideally, the surgeon should not cut into tissues that he/she does not understand AND cannot see with her/his own eyes. Therefore, sharp and blunt dissections must literally proceed "millimeter by millimeter." The dissection carefully spreads out and thins the adhesion, the scar, or the visceral connective tissues so that the operator can visualize the structures enveloped within. Surgical dissection must reveal structures, not obscure or confuse them. Therefore, knowledge of the structures contained in the area to be dissected and anatomic orientation during dissection are essential to meticulous and safe dissection techniques. This also requires the operator to think spatially in three dimensions. Additionally, the surgeon must learn the palpable "feel" of dissection. Remember, the operator only employs two of the five senses when performing a surgical procedure: sight and palpation. These two senses are equally important. These senses must be consciously developed, practiced, and improved by repetition and experience.

By dissecting "millimeter by millimeter," the surgeon achieves four goals. First is the maintenance of correct anatomic orientation and direction of dissection. Second is the allowance for reevaluation of dissection techniques and use of instrumentation. The surgeon has time to think from dissection step to dissection step, and change techniques, approach, or instrumentation, if needed. Flexibility, ingenuity, and experience are essential characteristics of the accomplished surgeon. Third is proceeding in small steps under direct visualization in order to safely reveal the vital anatomic structures to be safeguarded. Fourth is limitation of any injury to an anatomic structure by 1 mm or less. By dissecting deliberately and slowly, in most cases the operator can readily control any bleeding encountered or see an unavoidable injury to a viscus or anatomic structure. Therefore, major bleeding or gross visceral injury should be minimized.

There are several techniques that the operator must master. These techniques of surgical dissection are the same in any area of the pelvis no matter the route of entry to that anatomic area, whether by laparotomy, laparoscopy, or per vaginum. They are grasp and tent; "millimeter" incisions under clear visual control; push and spread; traction and countertraction; rotation and counterrotation of the grasped tissue; and gentle wiping of tissue by judicious blunt dissection. Some of these techniques can be facilitated by the technique of hydrodissection. Hydrodissection is the injection of sterile fluid into the tissues to be dissected in order to tent and thin these tissues. Again, these dissection techniques must be performed slowly and deliberately in small 1-mm increments.

By *grasping and tenting* the adhesion, scar, peritoneum, or visceral connective tissue, the operator in most cases elevates or moves the grasped tissue away from a viscus or vital anatomic structure, even if that distance is only 1 or 2 mm. Grasping and tenting also helps to thin out the grasped tissue so that an edge of bowel serosa may be seen, a ureter can be seen to undergo peristalsis, or an artery can be seen pulsating. With tenting and with anatomic knowledge and orientation, the surgeon can then *incise* the grasped tissue with a knife, scissors, or laser by 1 mm. The incision should be placed on the side away from any vital anatomic structure or organ. For example, adhesions from the uterus to the bowel should be incised on the uterine serosa, and not toward the bowel serosa. The techniques of tenting and traction–countertraction would be useful in this case.

With reevaluation of the incision, he/she can then carefully use a *push and spread* technique "millimeter by millimeter" to further expose the contents of the adhesion, scar, or visceral connective tissue. The tissue is further spread out and thinned by grasping the edges of the dissected tissues and gently pulling them apart by using *traction and countertraction*. Obviously, there is a "feel" to these maneuvers.

In some situations, gentle *rotation of the grasped tissue* will further thin the tissues and may reveal the underlying structures. *Rotation and counterrotation* can further fracture scars and adhesions to thin them out. In dense adhesions or scar tissue, sharp dissection with the knife or scissors or laser "millimeter by millimeter" can be augmented with gentle localized *wiping* "millimeter by millimeter" as a form of traction and countertraction. This technique is also known as "teasing the tissues." Broad, blunt strokes of the *wiping* technique are not to be used. Such quick, sweeping moves do not allow for controlled dissection. This is an uncontrolled, "blind" method of dissection that can tear into blood vessels, the bladder, or bowel. Another technique is the directed injection of sterile saline or other physiologic fluid into the dissection field. This technique, *hydrodissection,* further spreads, thins, and tents the tissues in a gentle manner. Hydrodissection can and does facilitate vaginal dissections in the vesicovaginal, paravaginal, rectovaginal, and paravaginal spaces.

YOU CANNOT OPERATE WITHOUT A "TEAM"

No matter how skilled and experienced you are as a surgeon, you cannot operate safely, efficiently, and effectively without an experienced team in the operating room. This team consists of you, your surgical assistant, scrub nurse, nurse circulator, and of course, your anesthesiologist. You cannot operate without a properly anesthetized, comfortable patient who has adequate muscle relaxation and does not move. You would waste your time if you had to take the time to gather your own instruments, sterilize them, and set them up on a sterile table. You would not be able to prep and drape your patient yourself and then insert cords into the machines surrounding the operating table without breaking scrub. In many cases, you cannot assist yourself during surgical dissections. In more challenging surgical cases, you will require additional personnel for retraction. You are the leader of a team that allows you to perform your best surgical techniques and procedures. You are a clumsy, grossly inefficient surgeon without them. The team allows you to shine forth. Better surgical results are achieved when there is a "synergy of purpose," with the members of the team working together to achieve a common purpose of safety and efficiency.

When the individual members of a team work independently or at odds with one another, the loss of cohesive respect fractures the quality and efficiency of the working environment. A tense, uncomfortable atmosphere in the operating room does not allow the optimal surgical result. First, do no harm. Professionals care about their behavior and performance. The entire team must be dedicated to patient safety and procedural efficiency.

Learn to be an appreciative leader. Your surgery will become smoother and better in a pleasant professional environment. Accept suggestions and compromise in order to improve surgical safety and procedural flow. Be mindful of the comfort of the team members, especially those who assist and retract. Appreciate team input during your surgeries. Your team members may give you information or reminders that you may not have noticed or remembered. You cannot observe everything that is going on in the operating room when you are focused on a small field of dissection. Your assistant may see something around the dissection field that you may not have seen. You may have been distracted when manipulating an instrument or performing a dissection.

Remember, there is no "I" in "TEAM," unless you are saying, "I am proud of our team." You have spent years in learning and developing your knowledge and skills in surgical anatomy, dissections, accepted procedures, judgment, and management of complications. However, you must remember you did very little of this development on your own. You had teachers, mentors, and experienced operating personnel to guide you and encourage you. Therefore, in return, you must develop an attitude of appreciation and respect for your team members—past, present, and future. Positive motivation should come willingly from within the individuals of the surgical team, not by fear of embarrassment or verbal punishment. The more you give to others in courtesy and respect, the more these people will give back by facilitating your surgeries. The atmosphere in the operating room will become respectful and comfortable. The members of the surgical team are your colleagues. Respect them. Teach them. Listen to them. Complement them. Everyone in surgery responds positively when part of a respected and successful team that brings the best care to each patient.

KEY STRUCTURAL ANATOMY

The vagina

The vagina is 8 to 10 cm in length and extends from the introitus through the urogenital diaphragm (Figure 1.1)[2]

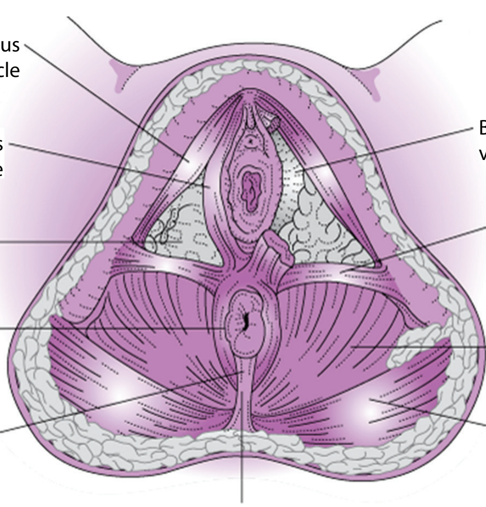

Figure 1.1 Structures of the female urogenital diaphragm. (From DeCherney A, et al., *Current Diagnosis and Treatment: Obstetrics and Gynecology*, 11th edition, McGraw-Hill Education, 2012. With permission.)

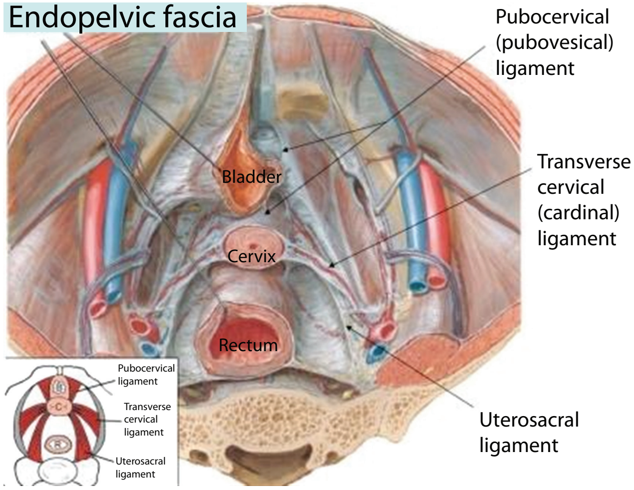

Figure 1.2 Key supportive fascial structures of the pelvis. (From Lawrence-Watt D, et al., Applied anatomy and imaging of the bladder, ureter, urethra, anus and perineum, in Flinders A, Thilaganathan B, eds., *MRCOG Part One: Your Essential Revision Guide*, 2nd edition, CUP, 2016. With permission.)

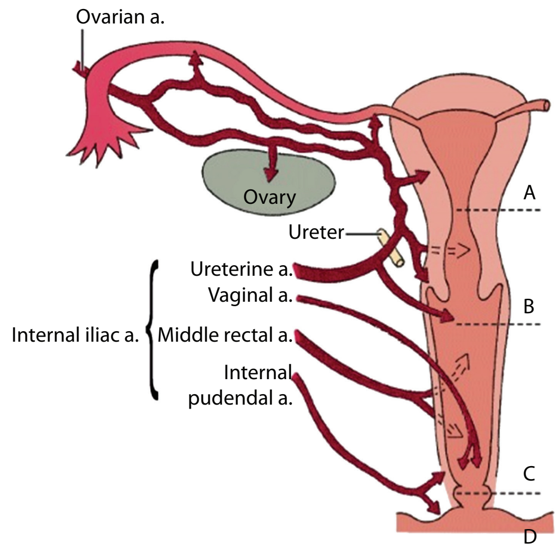

Figure 1.3 Blood supply of the vaginal uterus, and fallopian tubes. (From *Skandalakis' Surgical Anatomy*, Paschalidis Medical Publications, Athens, 2004.)

to the uterus. It can be divided into three essential parts including the vestibule between the labia minora, the vault up to the upper end of the vagina, and the fornices (anterior, posterior, lateral) or recesses formed as the vagina surrounds the cervix. The anterior and posterior vaginal walls are usually closely applied to each other, diverging at the vaginal vault and fornices. It is supported by various structures including the levator ani, the cardinal, pubocervical, and uterosacral ligaments; and the perineal membrane and body (Figure 1.2).[3] The vagina is anatomically related anteriorly to the cervix, bladder, and urethra, posteriorly to the pouch of Douglas and the perineal body, and laterally to the levator ani; pelvic fascia, and ureters. The arterial blood supply is complex from the vaginal, uterine, internal pudendal, and middle rectal arteries (Figure 1.3),[4] whereas venous drainage is via the vaginal venous plexus that drains into the internal iliac veins. The lymphatic supply of the vagina is by the internal and external iliac nodes for the upper three quarters and by the superficial inguinal nodes for the lower quarter. The nerve supply of the upper vagina is by parasympathetic fibers from the pelvic splanchnic nerves (S2 to S4), and by the pudendal nerve for the lower 2 to 3 cm (Figure 1.4).[3]

The uterus

The uterine corpus

Shaped like an inverted pear, the uterus is a hollow and muscular organ, measuring 7.5 cm in length, 5 cm wide at its upper part, and nearly 2.5 cm in thickness. As thin as 5 mm at the cornu, accidental perforation during sounding, dilation, or intrauterine surgery is more apt to occur at this location. In the normal uterus, the cavity is 4 to 5 cm long and 3 cm wide at the cornu. The upper expanded part is termed the corpus or body, the area of insertion of each fallopian tube is termed the cornu, and the part of the body above the cornu is termed the fundus. Given the broad horizon extending across the fundus to both cornu, a 30° optic is best suited to inspection of the uterine cavity. Anatomically, it is divided into the body, or corpus, and the cervix, with an interval narrowing known as the isthmus. The proximity of the ascending and descending uterine vessels at this anatomical junction magnifies the risk of hemorrhage during hysteroscopic resection procedures. The part of the body that lies above a plane passing through the points of entrance of the uterine tubes is known as the fundus. The cavity of the body is triangular and essentially flattened in contact anteroposteriorly. The uterine corpus comprises three layers: the outer serosal layer, which is the peritoneal covering of the uterus; the middle smooth muscle layer, the myometrium; and the inner mucous layer, the endometrium. The myometrium comprises an inner layer (junctional zone) and an outer layer, and represents the safe distance between any intrauterine instrument and the adjacent visceral and vascular structures. The transverse junction of the vesicouterine peritoneum with the uterine serosa forms a recognizable white line, above which the parietal peritoneum is fused while caudally is mobile and overlies loose fibrofatty tissue. Correspondingly, bladder flap development during hysterectomy is best performed below this white line and more apt to cause bleeding whenever mobilization is initiated above this white line.

The arterial blood supply of the uterus comes from both the uterine and ovarian arteries (Figure 1.3). The uterine artery is a branch of the anterior division of the hypogastric artery. It runs medially in the pelvis, within the base of the broad ligament to the outer surface of the uterus (Figure 1.5).[5] From lateral to medial, it has a descending, transverse, and ascending portion. The ascending portion runs alongside the uterus and passes anterior to the ureter (Figure 1.5) (Video 1.1). While this artery can be surgically

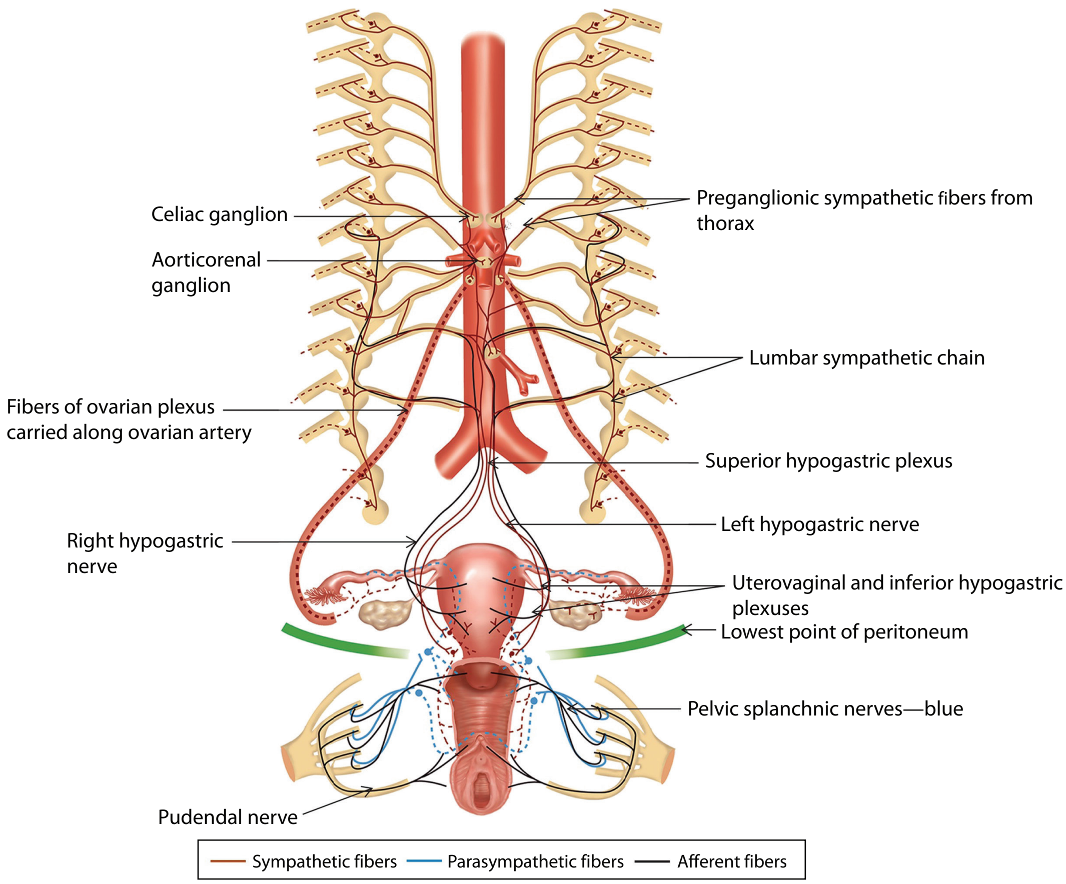

Figure 1.4 Innervation of the pelvic viscera. (From Lawrence-Watt D, et al., Applied anatomy and imaging of the bladder, ureter, urethra, anus and perineum, in Flinders A, Thilaganathan B, eds., *MRCOG Part One: Your Essential Revision Guide*, 2nd edition, CUP, 2016. With permission.)

skeletonized along its entire course up to the uterus, its close anatomical relationship to the lower uterine segment truncates accessibility and limits how well it can be isolated, compressed, and ultimately secured. Branches of the uterine artery include serpiginous offshoots to supply the uterus, a vaginal branch to the vagina, an ovarian branch to the ovary, and a terminal tubal branch to the fallopian tubes (Figure 1.3). The terminal branches of these vessels unite and form an anastomotic trunk from which the branches are given off to supply the uterus and fallopian tubes. The myometrium and endometrium are perfused by the progressive ramification and eventual penetration of the uterine artery into arcuate, radial, spiral, and basal branches to the level of the endometrium (Figure 1.6). The circumferential course assumed by the arcuate vasculature may argue for a transverse rather than midline myometrial incision during laparotomic or laparoscopic myomectomy procedures.

Afferent nerves from the uterus are to T11 and T12. The sympathetic supply is derived from the hypogastric and ovarian plexuses (Video 1.2), whereas the parasympathetic from the second, third, and fourth sacral nerves (Figure 1.4).

The lymphatic drainage of the uterus is to the para-aortic nodes for the fundus, the internal and external iliac nodes from the uterine body and cervix, and via the superficial inguinal nodes from the round ligament.

The biodynamics and anatomical support of the uterus are provided by the pubocervical fascia to the pubic bone anteriorly, the cardinal ligaments to the ischial spines laterally, and the uterosacral ligaments both posteriorly and apically to the anterior surface of the sacrum. Various pelvic support defects including uterine prolapse can be directly attributed to fundamental disruptions of these supportive structures and their key relationships (Figure 1.2). The uterus is juxtaposed anteriorly by the bladder and vesicouterine pouch; posteriorly by the rectum and pouch of Douglas; laterally by the proximal fallopian tubes, broad ligament, and uterine vessels; and inferiorly by the fornices of the vaginal canal (Figure 1.5).

Other than intrinsic anatomical propensity, the position of the uterus is susceptible to significant variation, depending upon the length of the uterosacral ligaments and the relative content of the bladder and the rectum.

The uterine cervix

The cervix is the lower component of the uterus projecting through the anterior wall of the vagina, which divides it into an upper, supravaginal portion and a lower, vaginal portion. The supravaginal portion is separated in front

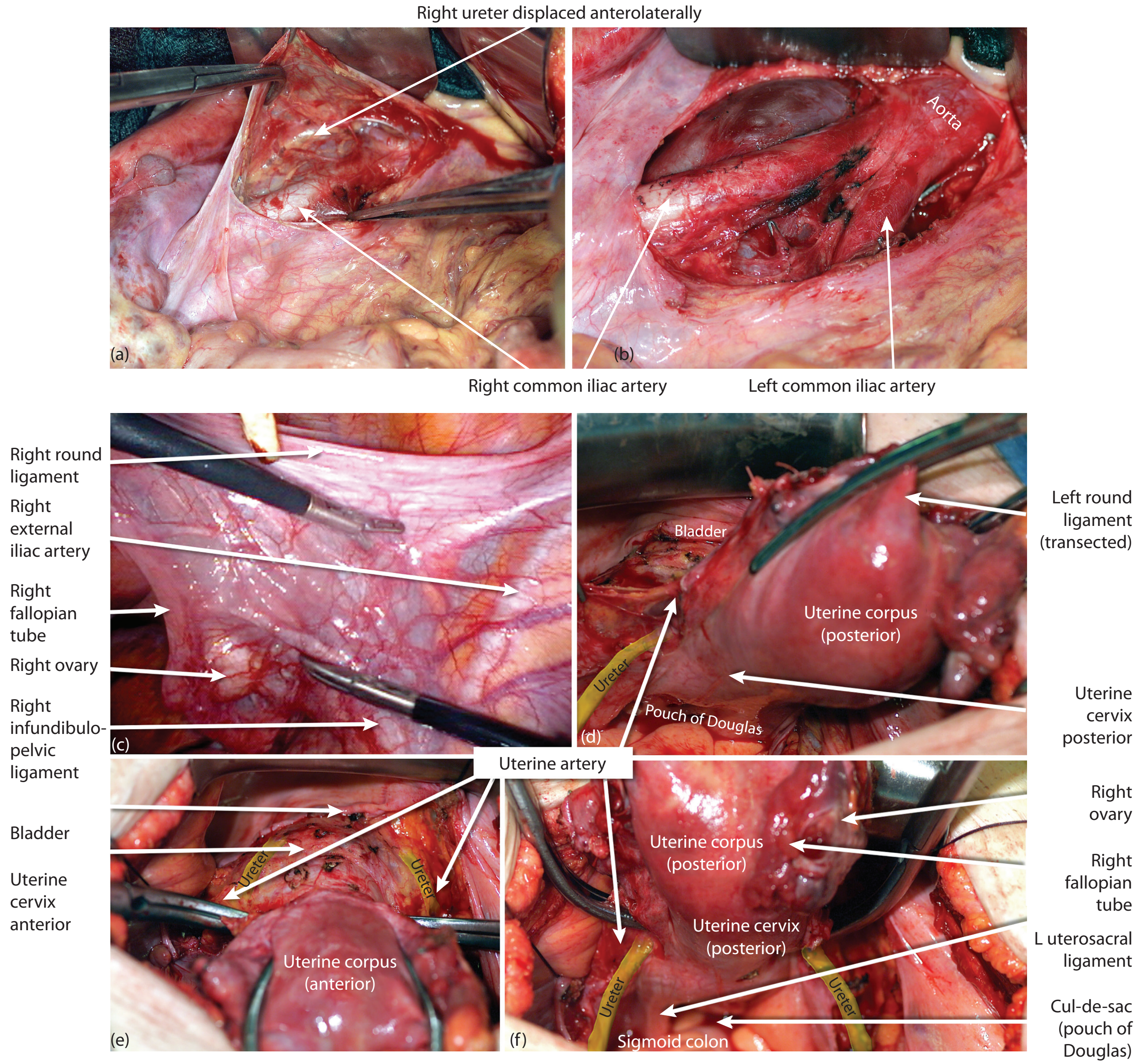

Figure 1.5 Topical and retroperitoneal anatomy. (a and b) Dissection at the aortic bifurcation. The right ureter has been lifted off the right common iliac artery. The uterus and surrounding structures are shown in the context of a laparotomic hysterectomy. The panel (c) demonstrates the superior attachments to the right pelvic sidewall including the right round and infundibulopelvic ligaments. The presumed course of the ureters is demonstrated with an overlay in the panels (d through f). (From Abu-Rustum NR, et al., eds., *Atlas of Procedures in Gynecologic Oncology*, 3rd edition, CRC Press, Boca Raton, 2013. With permission.)

from the bladder by the parametrium, which extends also onto its sides and laterally between the layers of the fibrous broad ligaments. The uterine arteries reach the margins of the cervix in this fibrous tissue, while on either side the ureter runs downward and anteriorly, coursing as close as 1 cm to the cervix (Figure 1.5) (Video 1.1). Posteriorly, the supravaginal cervix is covered by peritoneum, which extends to the posterior vaginal wall, where it is reflected onto the rectum forming the pouch of Douglas (Figure 1.5). The vaginal portion freely projects into the anterior wall of the vagina between the anterior and posterior fornices. The external os is bounded by the anterior and posterior lips, which normally are in contact with the posterior vaginal wall. The afferent nerve supply of the cervix travels back along the pelvic splanchnics (S2 to S4) and on the pudendal nerve (Figure 1.4).

The ovary

The ovaries lie within the ovarian fossa on the posterior wall of the true pelvis (Figure 1.5). The suspensory

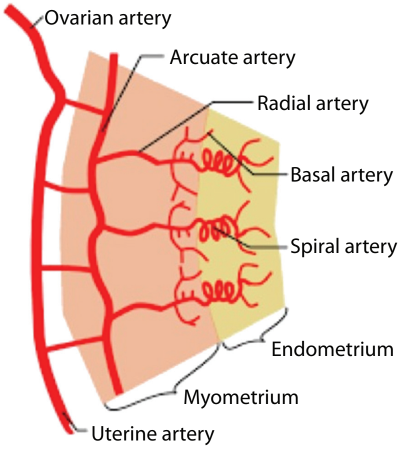

Figure 1.6 Myometrial and endometrial blood supplies. (Adapted from Robertson WB, *J Clin Pathol Suppl (R Coll Pathol)*., 1976;10:9-17.)

ligament of the ovary, a fold of peritoneum, runs from the sidewall of the pelvis to the ovary. The ovarian vessels run in this ligament, crossing over the external iliac vessels. Each ovary is attached to the back of the broad ligament by the mesovarium, which is continuous with its outer coat. The ovarian ligament attaches the ovary to the side of the uterus.

The arterial blood supply to the ovary is via the ovarian artery (Figure 1.3), whereas venous drainage is complex through the pampiniform plexus to the ovarian veins; the right drains into the inferior vena cava, whereas the left into the left renal vein.

Lymphatics travel with the ovarian vessels to the preaortic nodes. The nervous innervation of the ovaries is from aortic, renal, and superior and inferior hypogastric plexuses to form the ovarian plexus (Figure 1.4). The ovarian vessels typically arise from the aorta just inferior to the renal arteries and superior to the inferior mesenteric artery. They descend caudally in the retroperitoneum on the psoas major with the ovarian vein and ureter, into the pelvis anterior to the iliac vessels, and then in the pelvis along a medial path toward the uterus (Figure 1.5). They anastomose with the ovarian branch of the uterine artery at the uterus.

The fallopian tube

Bridging the ovary and uterus, the fallopian tube is a tubular structure of approximately 9 to 11 cm length. There is wide inter-individual variation. It is the site of ovum retrieval, ovum and sperm transport, sperm capacitation, fertilization, and later embryo transport.[7] The tubal environment also provides vital nutrient support for the dividing embryo. These mechanisms occur in various anatomic sections of the normal tube.

Cyclical changes in anatomic (ciliation, epithelial height), endocrinologic, and mechanical patterns[8–11] have been postulated or proven.[12] Although studies have elucidated certain aspects of tubo-ovarian interaction, not all have been verified in humans.[7,12–16]

The oviduct is made up of the fimbriae, infundibulum, ampulla, isthmus, and intramural (interstitial) tube. The fimbriae, the most distal portion of the oviduct, are relatively free and motile. The only attachment to the ovary is via the fimbria ovarica, one of about 25 fimbrial folds. Even this attachment is inconstant. The fimbriae attach to the infundibulum, a trumpet-shaped portion of the fallopian tube of 1 cm length. Like the fimbriae, it is thin-walled, is densely ciliated (60% to 80%),[17,18] and has a complex pattern of mucosal folds (Figure 1.7). Ovum retrieval and initial transport are affected by the close spatial relationship of the fimbriae to the site of ovulation.

The ampulla comprises approximately two-thirds of the total tubal length. Its luminal diameter decreases from 1 cm at the ampullary–infundibular junction to 1 to 2 mm at the ampullary–isthmic junction. The seromuscular layer is thin and composed of an incomplete internal longitudinal, a middle circular, and an external longitudinal layer. The mucosal folds within the ampulla are complex. The lumen is packed with these folds. Approximately 40% to 50% of ampullary cells are ciliated, while the remainder are serous secreting[19] (Figures 1.8 to 1.13). The inner longitudinal spiral myosalpingeal layer found in the ampulla is lost at the ampullary–isthmic junction.

The isthmus represents approximately one-third of tubal length (3 to 3.5 cm) and the lumen is considerably narrower than that of the ampulla (0.1 to 0.5 mm). The muscular layers are well developed. Isthmic ciliation is less profuse (25% to 30%) compared to the ampulla.[20] The isthmus has four primary mucosal folds (Figures 1.14 and 1.15).

The intramural or interstitial segment of the tube is short (10 mm) and narrow with a straight, arched, or convoluted course through the myometrium. It has been described as the junction between tube and uterus or, erroneously, as a sphincter, although no anatomic correlate to a sphincter has been documented. At the site of the junction of the endometrial funnel with the intramural portion of the tube, an abrupt change from endometrial to

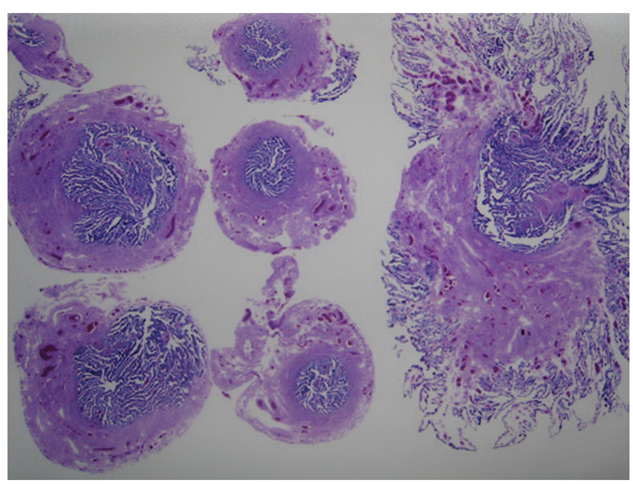

Figure 1.7 Light microscopy: cross sections of fimbria (right), ampulla (left), and isthmus (center) (hematoxylin and eosin stain).

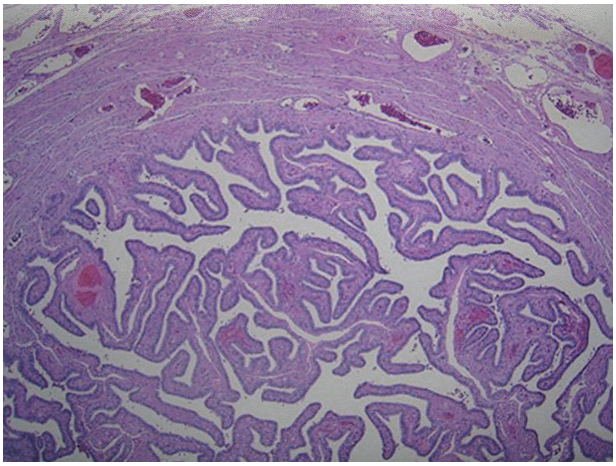

Figure 1.8 Light microscopy: cross section of human ampulla demonstrating complex folds of ciliated endosalpinx that fill the lumen (hematoxylin and eosin stain).

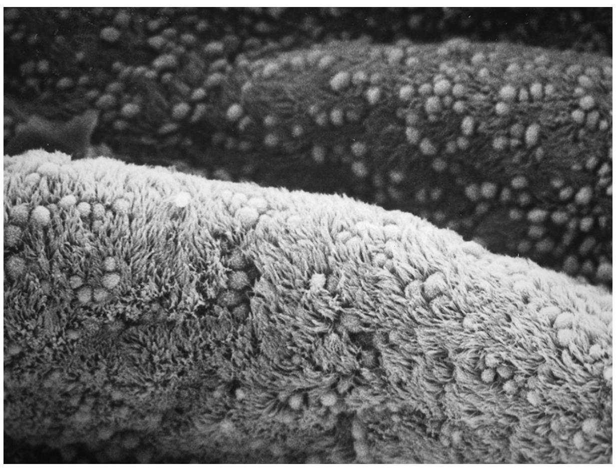

Figure 1.9 Scanning electron microscopy: ampulla of rabbit oviduct. Rugal fold of endosalpinx showing populations of ciliated and secretory cells. Magnification: 1700×.

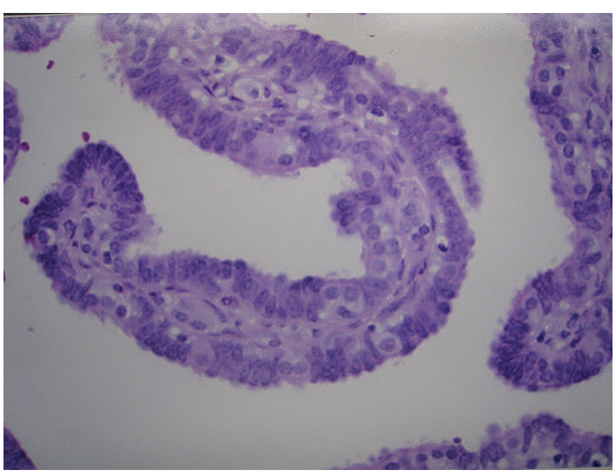

Figure 1.10 Light microscopy: cross section of ampullary fold of human endosalpinx.

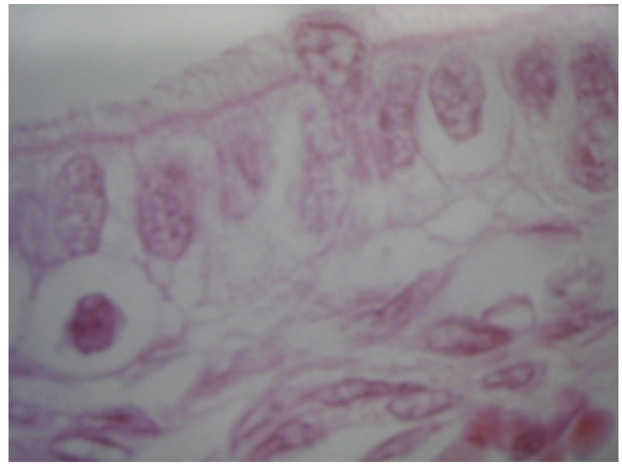

Figure 1.11 Light microscopy: detail of human ampullary endosalpinx showing ciliated cells (hematoxylin and eosin stain).

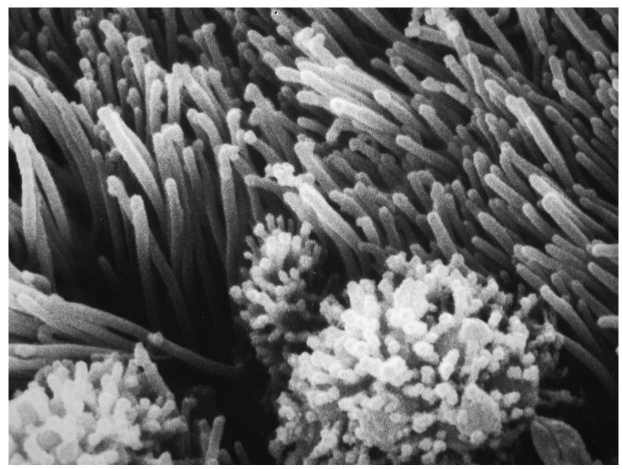

Figure 1.12 Scanning electron microscopy: detail of human ampullary endosalpinx showing ciliated cells.

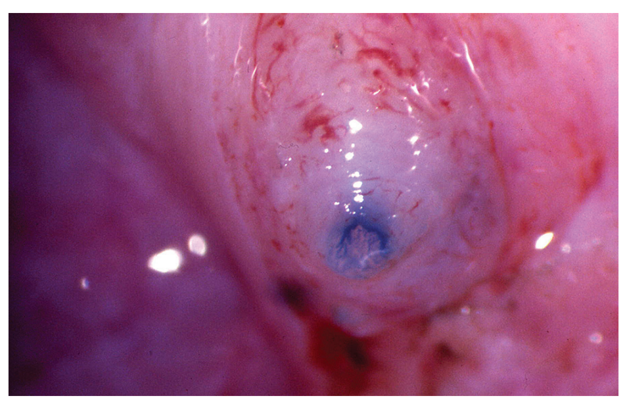

Figure 1.13 Microphotograph: cut surface of human isthmus.