CP OBGYN Clinical Perspectives in Obstetrics and Gynecology

Operative Gynecologic Endoscopy

J.S. Sanfilippo
R.L. Levine
Editors

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Series Editor:

Herbert J. Buchsbaum, M.D.

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With 156 Illustrations

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Editors:
Joseph S. Sanfilippo, M.D., Professor, Department of Obstetrics and Gynecology, University of Louisville School of Medicine, Louisville, Kentucky, USA

Ronald L. Levine, M.D., Clinical Professor, Department of Obstetrics and Gynecology, University of Louisville School of Medicine, Louisville, Kentucky, USA

Series Editor:
Herbert J. Buchsbaum, M.D., Professor and Chairman, Department of Obstetrics and Gynecology, Medical College of Wisconsin, Milwaukee, Wisconsin, USA

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To our families for their patience and
to our patients whom we care for as family.

Preface

It is becoming rapidly apparent that the discipline of gynecologic surgery is evolving into a specialty of increasing outpatient surgical expertise. Our mission in offering a comprehensive textbook on advanced endoscopic surgery and laser laparoscopy is to contribute to the education of interested clinicians and residents. We believe that an orderly sequencing of learning and application of knowledge is needed, and we think this text fits well into that sequence. This book allows the physician with skills in laparoscopy to gain the knowledge necessary to practice in the laboratory and ultimately to perform advanced endoscopic gynecologic surgery.

If indeed many current gynecologic procedures may be accomplished via endoscopic surgery, the clinician must have a reference to use when acquiring these skills. To quote Dr. Alan DeCherney (*Fertil Steril* 1985; 44:299): "The obituary of laparotomy for pelvic reconstructive surgery has been written; it is only its publication that remains."

The contributors to this text were chosen not only for their expertise but also for their clinical acumen in the field of endoscopic surgical application; both have been gained in a variety of American hospital settings, ranging from a small community hospital to a large urban university medical center. Because the number of contributors to this volume is large, some overlap of information is inevitable. We believe this approach enhances the usefulness of the textbook, as the reader may view each chapter as a self-contained work.

In April 1986 the first university course on operative laparoscopy in the United States was held in Louisville, Kentucky. Several members of that faculty have contributed to this text. It quickly became evident from the enthusiasm and interest among the faculty and participants at that meeting that a new era of operative gynecologic endoscopy was emerging. All of us were aware of the dearth of American input in this area of advanced gynecologic endoscopy. One of the goals of our book, therefore, has been to consider many of the unique aspects of practicing gynecologic endoscopy in America.

The interest in "what can be accomplished through the laparoscope" has enjoyed an exponential growth, fueled by the use of laser technology and the increasing availability of proper instrumentation for what is also termed pelviscopic surgery. The reader may note that the terms pelviscopic surgery and operative laparoscopy are used synonymously in this text. For consistency, we have made an effort to use the term operative laparoscopy, as it is the preferred, more widely understood designation in the United States. We concede that at present there is no consensus within the medical community about terminology; several contributors to this text favor the term pelviscopic surgery as more descriptive. Just as the terms laparotomy and celiotomy or Stein-Leventhal syndrome and polycystic ovarian disease are recognized as interchangeable, so we consider operative laparoscopy and pelviscopic surgery to be equivalent.

We have long been convinced of the benefits of this new modality for our patients. We believe that the material contained in this text will help to improve the health care of gynecologic patients and will have a substantial beneficial economic impact on the practice of gynecology. Significant reduction in health care costs has been a direct result of the application of advanced gynecologic surgical procedures, as addressed in one of our previous publications (*J Reprod Med* 1985;30:655). That paper reported a 69% reduction in the number of postoperative hospital days required for operative laparoscopy compared to those needed for laparotomy and an overall 49% reduction in hospitalization costs for identical surgical procedures performed via pelviscopic surgery compared to the cost for laparotomy.

We hope that this text will contribute to the education of interested clinicians, residents, and students, and perhaps inspire them toward safer and more imaginative applications of endoscopic surgery.

Acknowledgments. We wish to acknowledge the many authors and consultants for their excellent contributions, assistance, and advice. In particular, we are indebted to Douglas M. Haynes, M.D., for his excellent translation of Professor Kurt Semm's chapter on the history of this procedure as well as for his scholarly guidance. We owe many thanks to Leon Goldman, M.D., for his constructive thoughts and consultation. We also wish to express our sincere appreciation for the assistance and patience of Leta N. Weedman, our editorial assistant. Our gratitude goes also to Mary Milliner and Betty Jones for manuscript preparation and word processing.

We must give special thanks to the University of Louisville School of Medicine in its sesquicentennial year for creating an environment conducive to meeting new challenges and to our

colleagues in the Department of Obstetrics and Gynecology for their encouragement. The Department has always supported, both physically and ideologically, the acceptance of avant-garde ideas and techniques.

Last but not least, we must acknowledge the support and guidance of our wives, Patricia and Sonia, and our families. We thank them not only for their help and forbearance but most importantly for understanding the demands of our "mistress medicine."

Joseph S. Sanfilippo
Ronald L. Levine

Contents

Contributors

GREGORY T. ABSTEN, M.A.
President, Advanced Laser Services Corporation, Grove City, Ohio, USA; Consultant, Ohio State University Hospitals, Columbus, Ohio, USA

ALFRED E. BENT, M.D.
Assistant Professor of Obstetrics and Gynecology, University of California at Irvine, Irvine, California, USA; Assistant Medical Director for Gynecology, Women's Hospital, Memorial Medical Center, Long Beach, California, USA

DAVID CHARLES, M.D.
Former Professor and Chairman, Department of Obstetrics and Gynecology, Marshall University School of Medicine, Huntington, West Virginia, USA

JAMES F. DANIELL, M.D.
Clinical Associate Professor, Vanderbilt University Medical Center, Nashville, Tennessee, USA

MICHAEL P. DIAMOND, M.D.
Assistant Professor, Division of Reproductive Endocrinology, Department of Obstetrics and Gynecology, Yale University School of Medicine, New Haven, Connecticut, USA

JAMIL A. FAYEZ, M.D.
Professor of Obstetrics and Gynecology, Chief of Reproductive Endocrinology Section, Department of Obstetrics and Gynecology, The Bowman Gray School of Medicine, Wake Forest University, Winston-Salem, North Carolina, USA

HARRITH M. HASSON, M.D.
Associate Professor, Department of Obstetrics and Gynecology, Rush Medical College; Chairman, Department of Obstetrics and Gynecology, Grant Hospital of Chicago, Chicago, Illinois, USA

Douglas M. Haynes, M.D.
Professor Emeritus, Department of Obstetrics and Gynecology, University of Louisville School of Medicine, Louisville, Kentucky, USA

Louis G. Keith, M.D.
Professor of Obstetrics and Gynecology, Northwestern University Medical School, Chicago, Illinois, USA

Bryan Larsen, Ph.D.
Associate Professor of Obstetrics and Gynecology, Associate Professor of Microbiology, Marshall University School of Medicine, Huntington, West Virginia, USA

John M. Leventhal, M.D.
Clinical Instructor in Obstetrics and Gynecology, Harvard Medical School, Boston, Massachusetts, USA

Ronald L. Levine, M.D.
Clinical Professor, Department of Obstetrics and Gynecology, University of Louisville School of Medicine, Louisville, Kentucky, USA

Carl J. Levinson, M.D.
Clinical Professor, Department of Obstetrics, Gynecology and Reproductive Sciences, University of California at San Francisco; Chairman, Department of Obstetrics and Gynecology, Children's Hospital of San Francisco, San Francisco, California, USA

Linda F. Lucas, M.D.
Assistant Professor, Department of Anesthesiology, University of Louisville School of Medicine, Louisville, Kentucky, USA

Carolyn J. Mackety, R.N., M.A.
Director Nursing, Surgical Services, Medical Center Hospital, Burlington, Vermont, USA

John L. Marlow, M.D.
Assistant Professor of Obstetrics and Gynecology, George Washington University School of Medicine; Assistant Clinical Professor, Department of Obstetrics and Gynecology, Georgetown University School of Medicine; Chairman, Department of Obstetrics and Gynecology, Director, Continuing Medical Education, Columbia Hospital for Women Medical Center, Washington, DC, USA

Dan C. Martin, M.D.
Reproductive Surgeon, Baptist Memorial Hospital; Clinical Assistant Professor, Department of Obstetrics and Gynecology, University of Tennessee, Memphis, Tennessee, USA

MICHAEL W. METHOD, M.D., M.P.H.
Resident, Department of Obstetrics and Gynecology, David Grant Medical Center, Travis Air Force Base, California, USA

DONALD R. OSTERGARD, M.D.
Professor of Obstetrics and Gynecology, Director, Gynecologic Urology, University of California at Irvine, Irvine, California, USA; Associate Medical Director for Gynecology, Women's Hospital, Memorial Medical Center, Long Beach, California, USA

HARRY REICH, M.D.
Nesbitt Memorial Hospital, Kingston, Pennsylvania, USA

BENJAMIN M. RIGOR, M.D.
Professor and Chairman, Department of Anesthesiology, University of Louisville School of Medicine, Louisville, Kentucky USA

JOSEPH S. SANFILIPPO, M.D.
Professor, Department of Obstetrics and Gynecology, University of Louisville School of Medicine, Louisville, Kentucky, USA

KURT SEMM, M.D., V.M.D.HON.
Professor and Chairman, Department of Obstetrics and Gynecology of the Christian-Albrechts-University of Kiel and Michaelis School of Midwifery of Kiel, Federal Republic of Germany

STEVEN R. SMITH, J.D.
Dean and Professor of Law, Cleveland-Marshall College of Law, Cleveland State University, Cleveland, Ohio, USA

MARVIN A. YUSSMAN, M.D.
Professor, Department of Obstetrics and Gynecology, University of Louisville School of Medicine, Louisville, Kentucky, USA

1 History*

KURT SEMM

The idea and application of an endoscopic technique has enjoyed a long history in the medical sciences. Today, at the end of the twentieth century, we have initiated the transition from classic microsurgery, developed during the last decades, to that of "minimally invasive surgery." Endoscopy, ultrasonography, and laser surgery are the new instruments for the future surgeon. This chapter provides a historical perspective on the progression of pelviscopic and laser laparoscopic surgery from its earliest conception to the present.

The origin of endoscopy may be traced to a description in the Babylonian Talmud (Niddah Treatise, section 65b). This document described the use of a lead funnel with a bent mouthpiece equipped with a wooden drainpipe (Mechul) that, when introduced into the vagina, permitted the first direct visual inspection of an internal organ—the uterine cervix. The concept of "visualization," according to Avicenna (980–1037 AD) is attributable to the Arabian physician Albukassim (912–1013 AD). He was the first to use light reflected from a mirror placed in front of the exposed vulva to illuminate internal body structures for inspection.

The first endoscopic light source is attributed to Giulio Cesare Aranzi. In *Tumores Praeter Naturam* (Venice, 1587, Ch. 21, p. 172) he described the medical application of the *camera obscura*, which had been invented by the Benedictine monk Don Panuce. Leonardo da Vinci noted a type of *camera obscura* in 1519, but it was first so designated by Porta in *Magica Naturalis* (1589). Using the sun's rays directed through a chink in a shutter, Porta focused the rays through a filled round glass flask and directed them into the nasal cavity. For a cloudy day he recommended an artificial light source.

The vaginal speculum, developed over a span of centuries, was given new impetus by the gynecologist Arnaud (*Mémoires Gynécologiques,* 1768). He was the first to use the thief lantern, which was widely known and employed in his time as a lamp for medical endoscopic examination. However, for the birth of modern endoscopy, we must look to Bozzini[1] (1807) and his invention of the first light reflector. It consisted of an apparatus that directed light rays into the internal cavities of the body of a living animal and redirected them to the eye of the observer. The development of endoscopy culminated in the first practical endoscope of Desormeaux[2] in Paris. For the endoscopic model (submitted to the *Académie Impériale de Médecine* on 29 November 1865) he was awarded a portion of the Argenteuil Prize.

The photographic and television imaging that today represents the cutting edge of progress in abdominal endoscopic surgery was pioneered by Stein[3] in Frankfurt, where as early as 1874 his "photo-endoscope" (Fig.

*Translated by Douglas M. Haynes

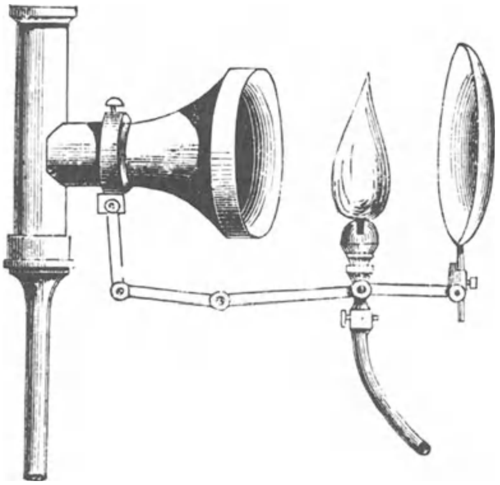

FIGURE 1-1. Stein cystoscope with light source and concave mirror.

1-1) was demonstrated. Although gynecology was the field that initiated endoscopy, no significant impetus for the further technical development of the endoscope came from this source after the mid-nineteenth century. From then on, only Desormeaux[2] (1865), Aubinais[4] (1864), and Pantaleoni[5] (1869) made significant endeavors to inspect the uterine cavity with the endoscopes at their disposal. Although gynecology was responsible for pioneering efforts in endoscopy, the primary technical development of the endoscope fell to the field of cystoscopy. The reason for this circumstance was that the light source attached to the tip of Nitze's[6] cystoscope (1879) did not present any hazard of injury, as the water in the urinary bladder solved the problem of appropriate cooling.

In 1901 Kelling[7] was the first to inspect the viscera of a dog whose abdomen had been insufflated with air; he named this procedure "celioscopy." The application of this new technique to humans was accomplished in 1910 by the Swedish physician Jacobaeus[8] under the designation of "laparoscopy." This method was allegedly rediscovered on two other occasions: in the United States as "abdominoscopy" by Steiner[9] in 1924 and in Italy as "splanchnoscopy" in 1935 by Redi.[10] The first textbook to deal with laparothoracoscopy was published by Korbsch[11] in 1927 in Munich.

It is not surprising that the new endoscopic technique, developed primarily for use by the surgically trained gynecologist, should have been promptly applied to general surgical procedures. In this vein, Fervers[12] reported in 1933 use of the coagulating sound of a cystoscope to lyse intraabdominal adhesions for the first time.

In 1936 in Switzerland, Boesch[13] published a paper on laparoscopy that described the "wonderful scanning views in the freely moveable female pelvic genitalia of the ordinarily invisible organs, such as the inspection of the ovaries" using an instrument called the elevatorium. He reported further: "At long last the laparoscope has provided us with a method of performing tubal sterilization without laparotomy. By means of an appropriately grounded coagulating clamp, the fallopian tubes are coagulated for 3–5 seconds via endoscopy under visual monitoring. . . ." Independent discovery of this method occurred in 1941 when Power and Barnes[14] used a peritoneoscope for tubal sterilization in Ann Arbor, Michigan.

The automatic needle had been developed earlier by Goetze,[15] in 1918 (Fig. 1-2). He used the automatic needle for the risk-free puncture and insufflation of the abdomen using oxygen.

Beginning in 1946, the Parisian gynecologist Palmer[16] followed up on these pioneering efforts by systematically developing the diagnostic endoscopic procedures of gynecology via celioscopy. Because the abdominal route in particular posed technical difficulties, Decker,[17] working in the United States after 1946, proposed use of the vaginal route because it is closer for the gynecologist. He developed culdoscopy as a standard procedure. Although widely used in America for some time, this technique dwindled in significance because the diagnostic work was unsatisfactory via the cul-de-sac of Douglas and did not permit development of surgical operative techniques. The trend to laparoscopy was further popularized in Germany from 1958 on by Frangenheim,[18] who preferentially used the abdominal approach.

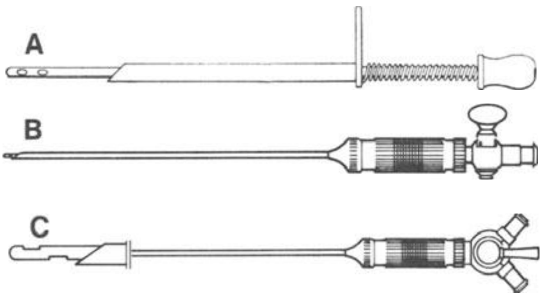

FIGURE 1-2. Injection needles for nonhazardous induction of pneumothorax or pneumoperitoneum. (A) Goetze (1918) insufflation needle with featherspring mechanism for induction of a pneumothorax; (B) Verres (1924) modification of (A) for induction of a pneumoperitoneum; (C) Semm (1972) modification for celiotonometry (this term refers to the monitoring of intraabdominal gas pressure). (Figures 1-2A and 1-2B reprinted from ref. 37, with permission of F.K. Schattauer, Stuttgart–New York. Figure 1-2C reproduced with permission from: Weitere Entwicklungen in der gynäkologischen Laparoskopie, Pelviskopie, Hysteroskopie, Fetoskopie by K. Semm, copyright 1978 Urban & Schwarzenberg, Baltimore–Munich.)

Whereas upper abdominal laparoscopy could easily be performed under local anesthesia and posed few practical hazards, laparoscopy of the lower abdomen carried with it a number of specific risks owing to the presence of the bowel and the great vessels. This fundamental difference between the relatively safe upper abdominal laparoscopy and the correspondingly hazardous lower abdominal procedure led gynecologists, beginning in the 1960s, to essentially abandon laparoscopy with the exception of endoscopy of the true pelvis—and that only for transvaginal culdoscopy.

In 1955 Fikentscher and Semm[19] developed the new Universal Insufflation Apparatus for diagnostic work on the fallopian tubes. Palmer[16] used his celioscopic technique principally for preoperative diagnosis in infertility patients. Because laparoscopy was virtually proscribed for gynecologic work in the university setting in Germany, the first insufflator using carbon dioxide, the "CO_2-Pneu," was developed by Semm for laparoscopic use in internal medicine. The use of this apparatus was documented in 1966 by Eisenburg.[20]

The automatic control system, as applied to the insufflation procedure for production of a pneumoperitoneum at the Medical Clinic of the University of Munich led ultimately to the stimulus that resulted in the official introduction of laparoscopy for gynecologic diagnosis in the second Munich University Women's Clinic in 1967.[21] With the

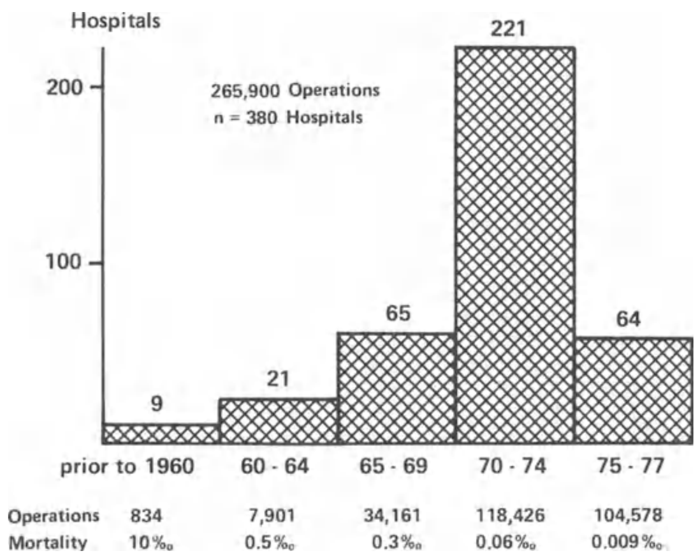

FIGURE 1-3. Precipitous increase in pelviscopic activity in Germany following introduction of cold light optics and the "CO_2-Pneu" after 1965 with a coincident drop in mortality. (Reprinted from ref. 38, with permission.)

simultaneous development of the "cold light" source—the extracorporeal fiberoptic system—the principal hazards inherent in the use of "gynecologic laparoscopy," i.e., burns and gas embolism, were overcome. Because the diagnostic procedure of gynecologic laparoscopy continued to encounter opposition, the designation "pelviscopy" was chosen in German gynecologic centers offering pelviscopic surgical procedures. Within 3 years this method had become widely accepted in Germany and remained so until 1969 (Fig. 1-3).

After the author's demonstration of the "CO_2-Pneu" to Melvin Cohen in Washington in 1967 and the promulgation of this device by publication of a small book on the subject,[22] the new procedure of pelviscopy grew exponentially in American gynecology. In the United States, in contrast to Europe, the method was limited to tubal sterilization, as had been suggested by Boesch 35 years earlier.[13]

Regrettably, the term "laparoscopy" led to conceptual confusion, which hindered the design and manufacture of specialized instrumentation and mechanical devices for gynecologic pelviscopy. The lack of knowledge of basic principles of physics as applied to the use of high-frequency currents in closed body cavities entailed the risk of occasional accidental injuries with serious sequelae. These circumstances greatly impeded progress in the use of the method.

In the United States, intensive research was promptly undertaken to eliminate the dangers of high-frequency current by such measures as shielding of instruments and reduction of current strength. Meanwhile, the author extended the scope of pelviscopy to include surgical operative procedures other than sterilization. As early as 1973 in New Orleans, the procedure termed endocoagulation was proposed for hemostasis.[23] With endocoagulation, the use of high-frequency current for the production of destructive temperatures was no longer required. Now the patient's body no longer made contact with the electrical current, as with unipolar or bipolar coagulation; optimal hemostasis could be obtained using a monitored maximum temperature of 100°C.

At this point, the history of advanced gynecologic laparoscopic surgery* can be said to begin. These advances can be considered from two aspects:

1. Steps in the history of the development of surgical instruments and other devices needed for operative pelviscopic surgery
2. Steps in the history of the development of pelviscopic operative procedures.
   a) Period of equivocal hemostasis, i.e., laparotomy sometimes required for definitive hemostasis
   b) Period of definitive hemostasis, i.e., using endocoagulation or endoligature and suture

Figure 1-4 provides a summary of the progressive development of surgical instruments and apparatus for operative pelviscopic surgery.

At first, the predominant hemostatic modality was the unipolar high-frequency device as originally employed by Boesch in 1936.[13] Following introduction of the fiber glass cable, the incandescent endoscopic tip became obsolete, eliminating the risk of burns. The "CO_2-Pneu," which was originally developed for use in internal medicine,[21] was crucial in facilitating rapid dissemination of the new pelviscopic technique. After extensive automation of devices to produce a pneumoperitoneum, there followed in 1968 the first pelviscope designed specifically for gynecologic use—the 5-mm-pelviscope with 30° visual point divergence. Because straight scissors deflect the tissues, the hook scissors (Fig. 1-5) were devised, allowing the operator to grasp and steady the tissue before it is severed.

The cervical adapter, described in 1959,[24] is sealed by suction onto the cervix and was used after 1969 for the atraumatic mobiliza-

* The Editors believe that "pelviscopic surgery" or "operative laparoscopy" are more encompassing terms than "pelviscopy"; therefore these terms are used interchangeably throughout this book.

Historical Steps by Devices

1935	High • Frequency • Coagulation / monopolar
1965	Thermo • Coagulator
1965	Cold • Light
1966	CO_2 • Pneu
1967	CO_2 • Pneu • Automatic
1968	Pelviscope
	Hook • Scissor
1969	Uterus Mobilizer by vacuum
1971	High • Frequency • Coagulation / bipolar
1972	Endocoagulator
1974	Crocodile • Forceps
1976	Applicator for Loopligation
1978	Electronic CO_2 • Pneu
1979	Endo • Ligation
	Tissue • Morcellator
1980	Endo • Suture
	Aquapurator
1982	Myoma enucleator
1985	Pelvi • Trainer
1986	Operations • Optic • Set
	Emergency • Needle

FIGURE 1-4. Development of apparatus and instrumentation for pelviscopic surgery in historical sequence.

tion of the uterus to permit simultaneous instillation of methylene blue (Fig. 1-6).

The first accidental injuries reported in the United States associated with sterilization procedures using high-frequency currents quickly led to appropriation of the bipolar application of high-frequency currents that had been used for decades in neurosurgery. The biopolar application greatly diminished the hazards inherent in the use of high-frequency current but did not eliminate accidents. Following extensive research, endocoagulation was introduced into gynecologic endoscopic surgery (Fig. 1-7) by means of miniaturization of the endocoagulation instruments that were developed after 1965 for cauterizing of the superficial layers of the portio epithelium in patients with benign leukoplakia ("erosion").[25] Using the crocodile clamp and the point coagulator, it was possible to secure definitive hemostasis without exposing the patient's body to direct contact with the electrical current. At the same time, the heat applied could be regulated with respect to magnitude and duration. As Figure 1-8 shows, surgical capability was quickly augmented at the University of Kiel, with increasing potential for prompt, reliable ability to control intraabdominal bleeding.

Along with the increased frequency of surgical intervention came the growth of enthu-

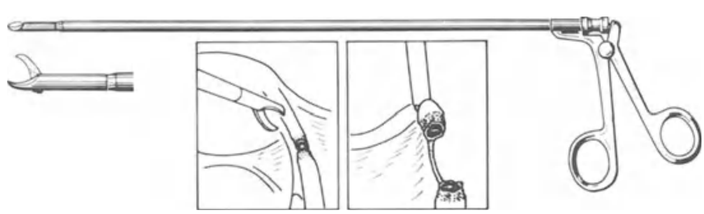

FIGURE 1-5. Hook scissors, originally developed for controlled grasping and transection of the fallopian tube.

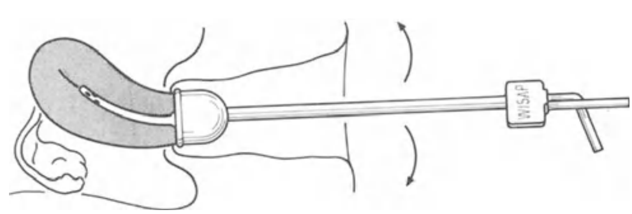

FIGURE 1-6. Semm vacuum cervical adaptor for simultaneous mobilization during pelviscopic surgery and tubal insufflation with carbon dioxide or dye solution.

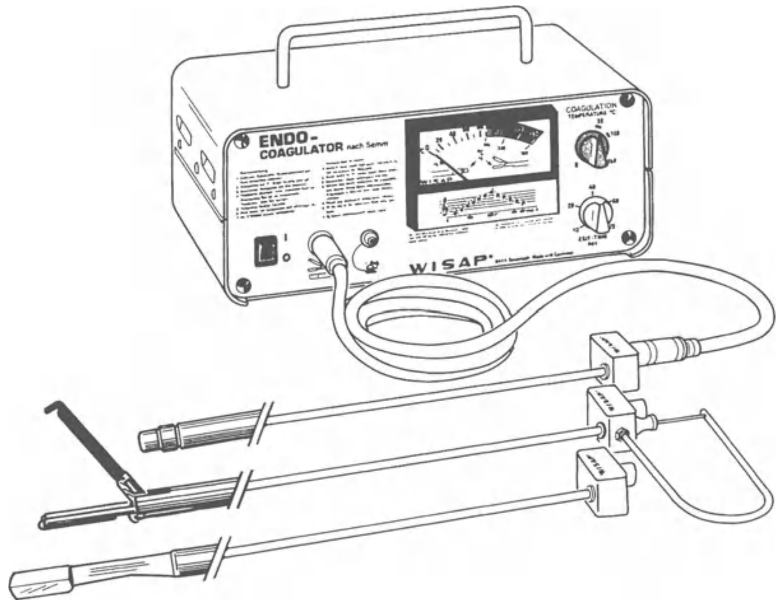

FIGURE 1-7. Semm endocoagulator for producing localized hemostasis at 100°C without contact of current with the body using point-coagulator, crocodile forceps and myoma enucleator instrumentation. (Reprinted from ref. 29, with permission and courtesy of WISAP, Sauerlach, West Germany).

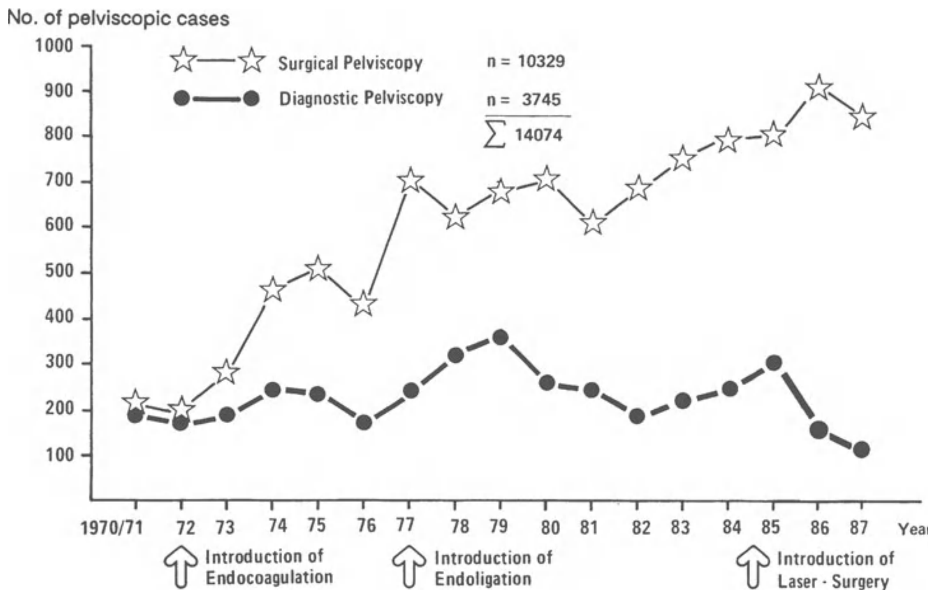

FIGURE 1-8. Increase in surgical pelviscopic activity in the Women's Clinic of the University of Kiel, 1971–1987, following the introduction of endocoagulation in 1972, the endoligature in 1977, and the laser in 1984. (Reprinted from ref. 29, with permission.)

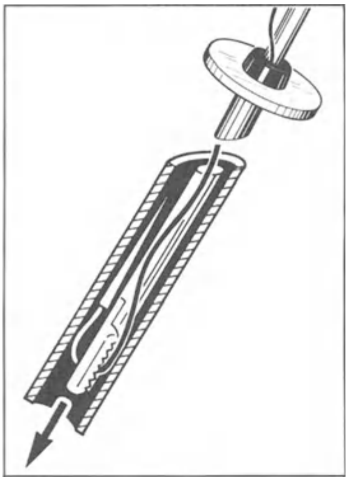

FIGURE 1-9. Applicator for needle holder and suture thread for endoscopic suturing.

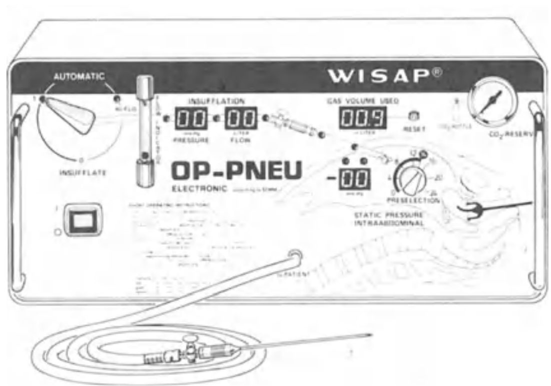

FIGURE 1-10. Semm "OP-Pneu-Electronic" device for monitored induction of pneumoperitoneum with digital indication of insufflation pressure and volume, and documentation of the intraabdominal static pressure and the total volume of gas used corresponding to the Semm monofil-bivalent system (see Fig. 1-11). (From Semm K: Operative pelviscopy: an alternative to laparotomy. Women's Wellness 1988;2(2):6. Reprinted by permission of publisher, B.C. Decker, and courtesy of WISAP, Sauerlach, West Germany.)

siasm for pelviscopic surgery. However, the risk that major hemorrhage might no longer be controllable by destructive heat coagulation also increased.[26] As an outgrowth, the principle of the Roeder's loop was proposed after a patient was encountered in whom severe bleeding refractory to mechanical coagulation following lysis of filmy adhesions had motivated preparations for laparotomy. In this first case, it was possible to use the endoloop in the pelvic cavity only by complete loss of the pneumoperitoneum. This limitation led to the development of the loop applicator (Fig. 1-9)

Along with the capacity to isolate the adnexa in a bloodless manner using the triple-loop technique, there logically followed a requirement to ligate tissue secured by a snare and to transfix the tissue beforehand. It had long since been established that previous abdominal surgery posed no contraindications to operative laparoscopy. For this reason, specific emergency situations motivated the pioneers to formulate procedures for endoscopic loop-ligature and, shortly thereafter in 1978, for extra- and intracorporeal knot-tying.[26,27]

As the number of instruments and their associated interchangeability increased, the "CO_2-Pneu" apparatus developed in 1967 no longer compensated for the problem of loss of insufflated intraabdominal pneumoperitoneum. Under the influence of state-of-the-art techniques and principles for mensuration and monitoring, the "OP-Pneu-Electronic" system was developed (Fig. 1-10). The monofil-bivalent system (MBS)[28] provides safety for the patient (Fig. 1-11), even though the automatic adjustment is capable of providing a gas insufflation rate of 7 liters per minute.

An instrument, which in its basic form was already well known in operative cystoscopic work for curettage of prostatic adenomas, was then modified for use as a morcellating device for pelviscopic purposes (Fig. 1-12). It is now in use as an electronic "Auto-Morc" (WISAP, Sauerlach, West Germany).

Gradually, the operative procedures became progressively more difficult, leading to the requirement of an irrigating device analogous to those used for laparotomy. The Aquapurator was developed for this purpose (Fig. 1-13).

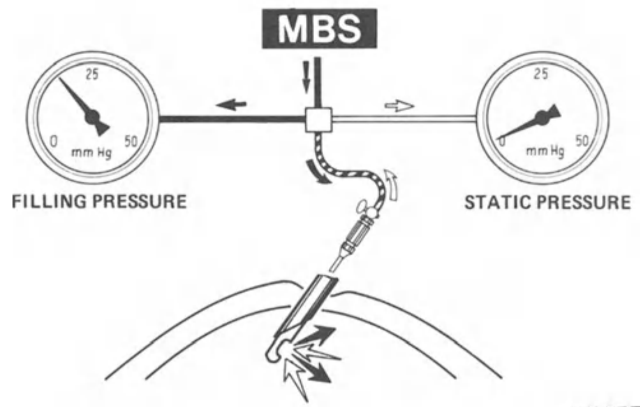

FIGURE 1-11. Monofil-bivalent system (MBS) for alternating measurement of the intraabdominal static pressure for guidance of the automatic filling mechanism of the Semm "OP-Pneu-Electronic" device. The static pressure is measured via the same insufflation opening, obviating possible insufflation failure because of erroneous pressure mensuration. (Reprinted from ref. 34, with permission; courtesy WISAP, Sauerlach, West Germany.)

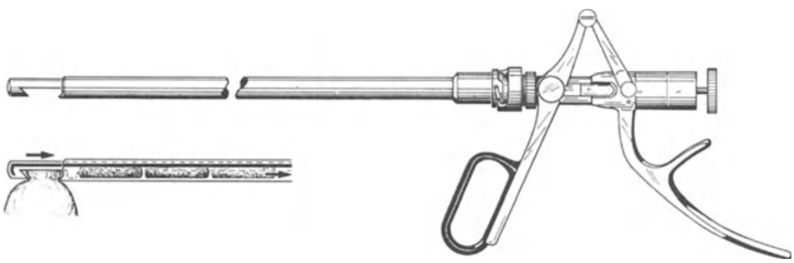

FIGURE 1-12. Semm morcellator for reduction of ovarian or myoma dimensions to permit their removal from the abdominal cavity through an 11-mm trocar sleeve. (Reprinted from ref. 37, with permission of F.K. Schattauer, Stuttgart–New York.)

Improvement in the technical sophistication of the newly developed endocoagulation procedures led to the elaboration of a cutting coagulator, the myoma enucleator. This instrument was developed primarily only for myoma enucleation but is also useful for bloodless and recurrent free ovariolysis and fimbriolysis.

The influx of these various new instruments created the need for a standard training program so surgeons could familiarize themselves with the advancing technology in the laboratory. The development of the "Pelvi-Trainer"[29] made it possible for the surgeon to learn and practice all the steps of "feasible intraabdominal operative procedures" without endangering the patient. The surgeon could practice with dummy materials such as placental tissue or the freshly extirpated uterus (Fig. 1-14).

With improvements in the optical properties of the "pelviscope" on the one hand and the proliferation of available instruments and devices on the other, the surgical possibilities increased. Two developmental periods followed over the space of a few years.

The first period encompassed the time before 1972. This period of development (Fig. 1-15) was characterized by the requirement for laparotomy in the event of bleeding that

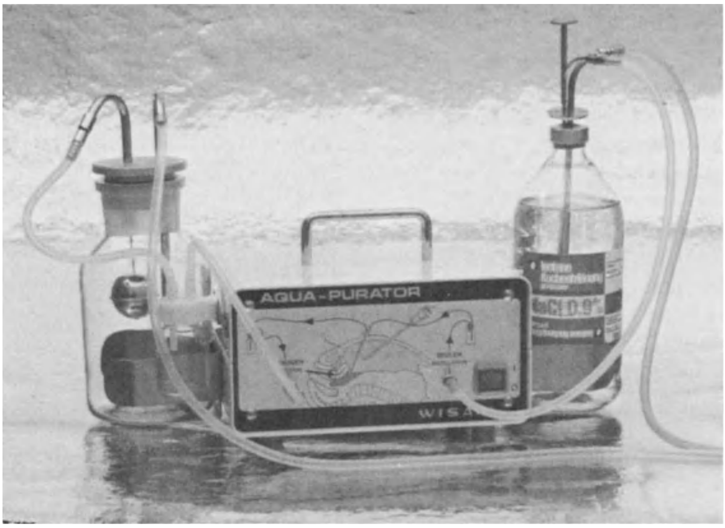

FIGURE 1-13. Semm Aquapurator for monofil-bivalent irrigation of the abdominal cavity with warm (37°C) physiologic solution through a virtually clog-proof hose system. (Reprinted from ref. 37, with permission of F.K. Schattauer, Stuttgart–New York and WISAP, Sauerlach, West Germany.)

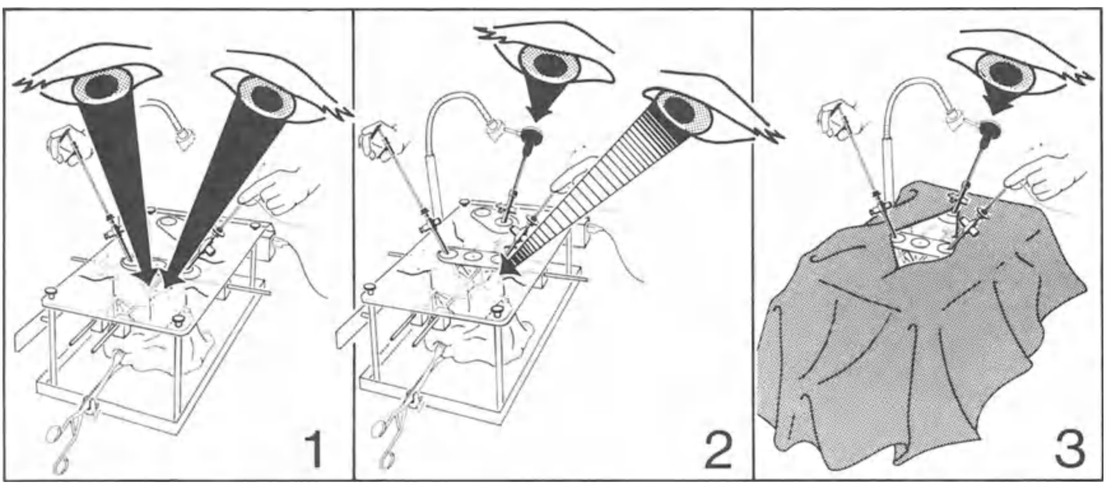

FIGURE 1-14. Semm Pelvi-Trainer for instruction in stepwise operative procedure in the laboratory. (1) The operator practices grasping, cutting, and suturing with visual monitoring through a transparent glass simulated abdominal wall. (2) The operator learns the appropriate operative sequences through the pelviscope and is able to check any mishaps through the "glass abdominal wall." (3) The Pelvi-Trainer is covered by a cloth, and all the operative steps are carried out exclusively through the pelviscope. (From ref. 36, with permission.)

Historical steps by ORGANS

problematic hemostasis period

1936 Tubal Sterilization by High Frequency Current
1946 Ovarian Biopsy
1950 Fimbriolysis
1976 Tubal Sterilization by CLIP
" " " RING

if increased bleeding occurs → LAPAROTOMY

FIGURE 1-15. Chronologic representation of the development of operative pelviscopic surgery during the era when hemostasis problems often required laparotomy.

could not be safely controlled by means of unipolar high-frequency coagulating current. Accordingly, feasible procedures were limited to cautious lysis of adhesions, ovarian biopsy, and fimbriolysis. The worldwide spread of pelviscopic surgery involved the indication for tubal sterilization in more than 90% of instances.

The second period is the time after 1972. As has already been indicated in Figure 1-8, the number of surgical procedures performed began to increase significantly as reliable methods of hemostasis were developed. Along with sterilization by endocoagulation, the earliest operative successes involved cases of sterility caused by peripheral tubal occlusion. In Kiel, pelviscopic salpingostomy increasingly supplanted microsurgical procedures via laparotomy. Figure 1-16 provides a chronologic summary of the incorporation of standard gynecologic operations into the "pelviscopic repertoire." Endocoagulation also made it possible from 1975 on to excise and morcellate small pedunculated myomas.

The operative surgery described in subsequent chapters, in the full sense of the term, first began in 1976 with the introduction of the Roeder loop for suturing.[26,27] Extensive lysis and resection of adhesions became feasible using the Roeder loop for problem-free control of potential bleeding. Extended adhesiolysis of omental adhesions and resection of omentum, etc. soon became possible. The first salpingectomies, oophorectomies, and adnexectomies followed, in that order. The "triple-loop" technique ensured a high degree of safety and made it possible to operate on tubal ectopic pregnancies, whether treated conservatively under microsurgical conditions with microsutures or by salpingectomy[30] (see Chap. 5).

Historical steps by ORGANS

safety hemostasis period

1972 STERILIZATION by Endocoagulation
1974 SALPINGOSTOMY " "
1975 Myoma enucleation " "
1976 TUBAL PREGNANCY radical
1977 OMENTUM - ADHESIOLYSIS or Resection with Loop-Ligation
1977 TUBAL PREGNANCY conservative
1977 ADNEXECTOMY by „ 3 - Loop - Ligation"
1978 SALPINGOSTOMY by Endosuture (extracorporeal knot)
1980 BOWEL - ENDOSUTURE
1982 APPENDECTOMY by Endosuture (endo–, extracorporeal knot)
SINCE 1983 over 70% of gynecologic intraabdominal SURGERY by → PELVISCOPY

FIGURE 1-16. Chronologic development of pelviscopic operative methods after the introduction of reliable endoscopic hemostatic procedures.

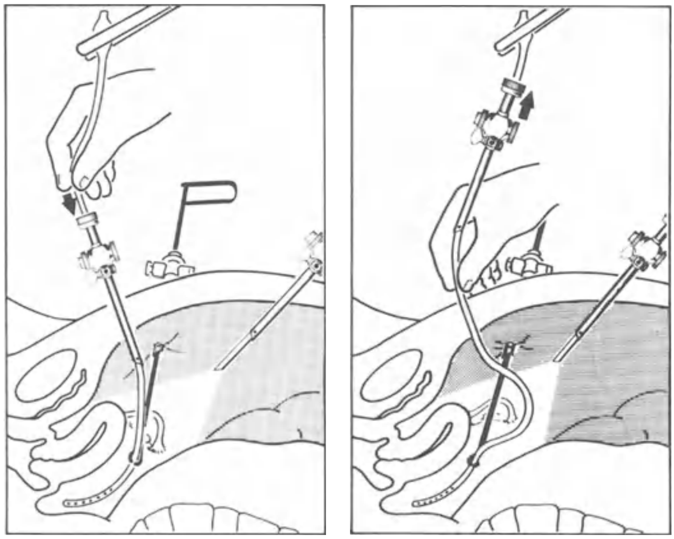

FIGURE 1-17. Postpelviscopic drainage of the cul-de-sac of Douglas through a 5-mm trocar using Robinson drainage (closed system) for reliable removal of postoperative exudate and prompt recognition of untoward bleeding. (From ref. 32, with permission.)

Surgical capability increased exponentially in 1977 when the Roeder loop was supplemented by the development of the endoligature and immediately thereafter by the endosuture with extracorporeal knot techniques (see Chap. 3). It was then possible to encircle or transfix and ligate tissues before severing. It even became possible to correct defects in the peritoneum, myometrium, and ovary following enucleation of cysts by apposing wound margins according to standard surgical principles.

The catgut suture material in use when these suturing and ligature techniques were developed was too coarse for microsurgical suturing after salpingostomy or serosal suturing following bowel injury.[31] Accordingly, the technique of instrumental knot-tying, already in use in microsurgery via laparotomy, was incorporated into pelviscopic surgery. In 1982 this technique fulfilled the prerequisites for appendectomy as well as those for lysis of extensive bowel and gastric adhesions with appropriate suturing of serosa or muscularis after successful mobilization. Ectopic tubal pregnancy could then be managed through the laparoscope by longitudinal salpingotomy and microsutures with extracorporeal knot techniques. With this procedure, the production of local ischemia by infiltration of the mesosalpinx with vasopressin (0.5% solution) was highly advantageous (see Chap. 5).

These extensive manipulations in the operative field inevitably produced increased postoperative wound secretion and oozing of blood. The routine placement of a Robinson tube for drainage (Fig. 1-17) provided immediate postoperative control of complications such as hemorrhage.[32]

As early as 1971, Hasson[33] had attempted to eliminate the fundamental hazard of the "blind" puncture by means of "open laparoscopy." This technique is presented in Chapter 4. A technique developed by the author in 1988, "visually monitored peritoneal puncture," is presented in Figure 1-18.[34] It has given us the confidence to extend the scope of operative pelviscopic surgical procedures in the abdomen, thereby allowing diagnosis of adhesions prior to perforation of the peritoneum. Even the abdomen that has been subjected to multiple prior laparotomies is no longer a contraindication to pelviscopic surgery; on the contrary, the previously operated abdomen is today one of the main indications for this procedure. Therefore gynecologic pelviscopic surgery has now become a model for use in general surgical procedures in the abdomen.[35]

As stated previously, the history of pelviscopic surgery began in 1965 in Munich.[21]

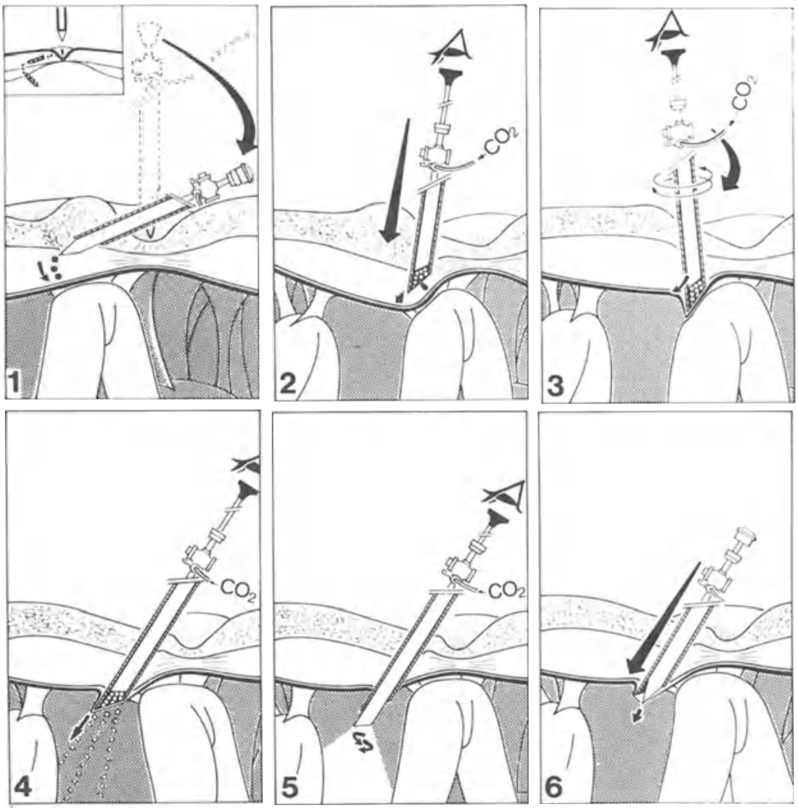

FIGURE 1-18. Transumbilical puncture of the abdominal wall is done under direct vision with the 5-mm optically equipped trocar after induction of pneumoperitoneum with the Verres needle (routinely possible even in the presence of abdominal adhesions after carrying out the seven necessary safety precautionary steps) as follows. (1) Introduction of the Semm elliptically shaped trocar and a cone-shaped trocar sleeve according to the Z-stick procedure only up to the rectus muscle. (2) After straightening of the cone-shaped trocar sleeve, the conical trocar is exchanged for the pelviscope, and the tip of the elliptical trocar sleeve is pushed through the rectus muscle with a twisting and turning motion. (3) The elliptical edge of the trocar sleeve has reached the fascia and peritoneum, respectively, and the operator encounters an opaque white color. (4) By means of lateral motion the elliptical trocar sleeve reaches the glistening peritoneum and vessels can be recognized. (5) By continual turning and pushing movements, the peritoneum is perforated and the free abdominal cavity is reached, constituting convincing evidence that the perforation has taken place at an unobstructed point in the peritoneum. (6) If thickened rectus fascia or peritoneum should prevent simple perforation with the trocar sleeve, the optical unit is exchanged for the cone-shaped trocar, steady pressure of which is followed by perforation. (Reprinted from ref. 34, with permission.)

Until the present, the scope of such operations could be summarized by the following synopsis arranged by the organs in question: pelviscopic operations on the uterus and adnexae (conservative procedures followed by radical procedures) as well as for extrauterine pregnancy, treatment for endometriosis, follicular puncture and gamete transfer, lysis of intraabdominal adhesions, procedures performed on the bowel, surgical procedures such as appendectomy, and, most recently, cancer diagnosis (Fig. 1-19).

PELVISCOPIC SURGERY

1. ... at the UTERUS
1.1. Management in case of perforation
  1.1.1. ... by sonde, curette, etc.
  1.1.2. ... by IUD
1.2. Myoma enucleation
  1.2.1. ... of subserosal fibroids
  1.2.2. ... of intramural fibroids
1.3. Enucleation of extrauterine fibromas

PELVISCOPIC SURGERY

2. ... conservative at the ADNEXA
2. 1. ... Ovariolysis
2. 2. ... Ovarian biopsy
2. 3. ... Ovarian cyst punction
2. 4. ... Ovarian cyst enucleation
2. 5. ... Fimbriolysis
2. 6. ... Salpingolysis
2. 7. ... Fimbrioplasty
2. 8. ... Salpingostomy
2. 9. ... End–to–End anastomosis
2.10. ... Removal of MORGAGNI's HYDATID
  2.10.1. ... pediculated
  2.10.2. ... retroperitoneal
2.11. ... Parovarian cyst–enucleation
2.12. ... Partial ovarian resection

PELVISCOPIC SURGERY

3. ... total at the ADNEXA
3.1. ... Ovariectomy
3.2. ... Tubal Sterilization
3.3. ... Tubectomy
  3.3.1. ... partial
  3.3.2. ... total
3.4. ... Adnexectomy

PELVISCOPIC SURGERY

4. ... in case of ECTOPIC PREGNANCY
4.1. ... in the FALLOPIAN tube
  4.1.1. ... total
  4.1.2. ... conservative
4.2. ... in the ovary
4.3. ... in the abdominal cavity

PELVISCOPIC SURGERY

5. ... of ENDOMETRIOSIS
5.1. ... on the peritoneum
5.2. ... within the sacro–uterine ligaments
5.3. ... on the surface of ovary
5.4. ... within the ovary
5.5. ... within the uterus
5.6. ... at the FALLOPIAN tube
5.7. ... on the bladder roof
5.8. ... on the bowels
5.9. ... retrocervical

PELVISCOPIC SURGERY

6. ... FOLLICULAR puncture and GAMETE transfer
6.1. IVF–ET (In–Vitro–Fertilization and Embryo–Transfer)
6.2. GIFT (Gamete–Intra–Fallopian–Tube–Transfer)
6.3. IUI (Intra–Uterine–Insemination)
6.4. IPI (Intra–Peritoneal–Insemination)

PELVISCOPIC SURGERY

7. ... for intraabdominal ADHESIOLYSIS
7.1. ... in the lower abdomen
7.2. ... in the middle abdomen
7.3. ... in the upper abdomen

PELVISCOPIC SURGERY

8. ... at the BOWEL
8.1. Bowel adhesiolysis (parietal peritoneum)
8.2. Bowel adhesiolysis (visceral peritoneum)
8.3. Bowel–Omentum adhesiolysis and resection
8.4. Appendectomy

PELVISCOPIC SURGERY

9. ... for Intraabdominal CANCER VERIFICATION
9.1. Substitution of explorative laparotomy
9.2. Aspiration of ascites
9.3. Tumor biopsy
9.4. Tumor mass reduction
9.5. Tumor staging

FIGURE 1-19. Organ-oriented classification of operative pelviscopic procedures.

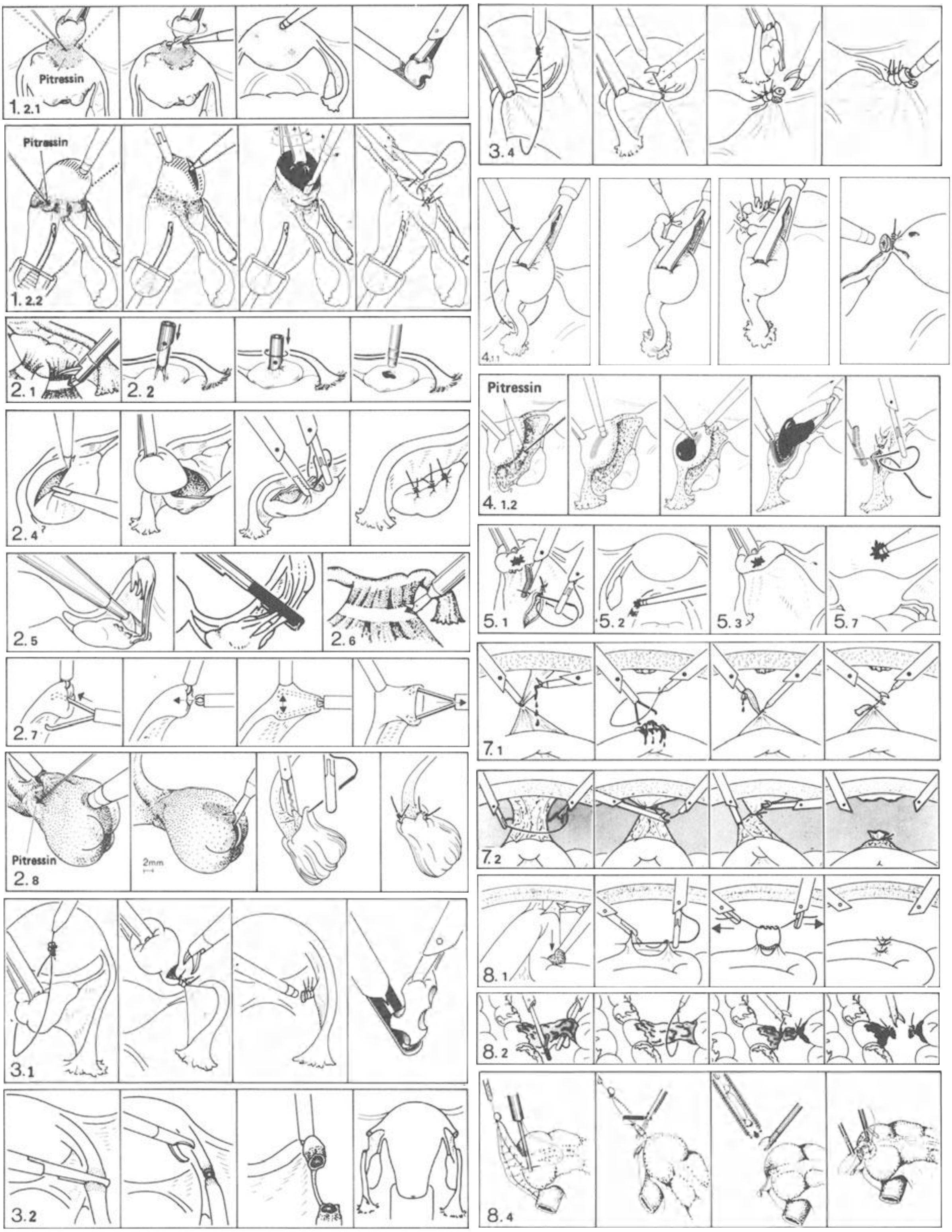

FIGURE 1-20. Synopsis of the feasible operative pelviscopic procedures listed in Figure 1-19.

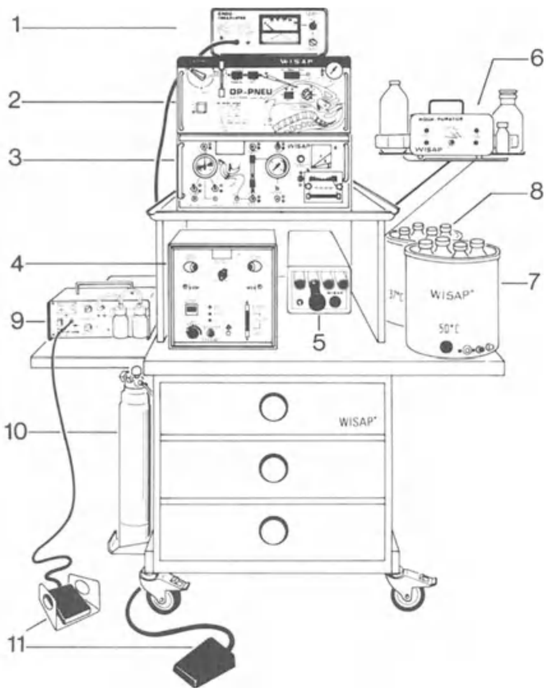

FIGURE 1-21. Cart for overall visibility and practical display of mechanical apparatus for endoscopic surgery. (1) Endocoagulator. (2) "OP-Pneu-Electronic" machine. (3) Fikentscher-Semm all-purpose pertubation apparatus. (4) Light source. (5) Optical attachment warmer, (6) Aquapurator. (7) Optic cleaner (50°C). (8) Container for abdominal irrigation fluid (37°C). (9) Aspirator for follicular aspiration material. (10) CO_2 gas canister. (11) pneumatic (nonelectrified) foot pedal. (Reprinted from ref. 37, with permission of F.K. Schattauer, Stuttgart–New York, and WISAP, Sauerlach, West Germany.)

Figure 1-20 presents all pelviscopic operations that have been performed in Kiel, West Germany, to date. With meticulous use of the available instrumentation and after preliminary training in each operative step using a pelvic trainer,[29,36] it is now possible to substitute operative pelviscopic surgery for gynecologic laparotomy in at least 75% of all cases presenting with standard indications for this procedure.[37] A prerequisite is, of course, the availability of, in good working condition, all the mechanical devices developed for operative laparoscopic surgery as well as the entire range of special instruments to grasp, puncture, cut and suture (Figs. 1-21 and 1-22). Lasers (CO_2, argon, KTP, and neodymium:YAG) are also available for bloodless adhesiolysis of small vessels. The classic hemostasis technique of loop ligation or endoligation must be available if more substantial bleeding occurs in order to avoid a laparotomy if possible.

More than 14,000 pelviscopic procedures have now been undertaken and evaluated in Kiel (Fig. 1-8). Because all patients who are candidates for operative pelviscopic surgery are prediagnosed by vaginal sonography and counseled for the possibility of laparotomy—a point of fundamental contrast with laparoscopy, in which subsequent laparotomy may be regarded as a technical error of judgment—a pelviscopic procedure is undertaken with full anticipation of laparotomy, i.e., with optimal safety precautions. The large number of evolving qualified gynecologists trained in pelviscopic surgery (operative laparoscopy) noted in this volume attests to the fact that near the end of the twentieth century pelviscopic surgery is regarded worldwide as a recognized method of choice for the correction of gynecologic pathologic entities. Pelviscopic surgery has been the pacemaker for "minimally invasive surgery" replacing the classic laparotomy in more than 80% of gynecologic procedures.

In the field of gynecology, endoscopic surgery may replace laparotomy in more than 80% of cases. In the twenty-first century, laparotomy may be indicated only for organ transplantation, tumors, and malignant tumors.

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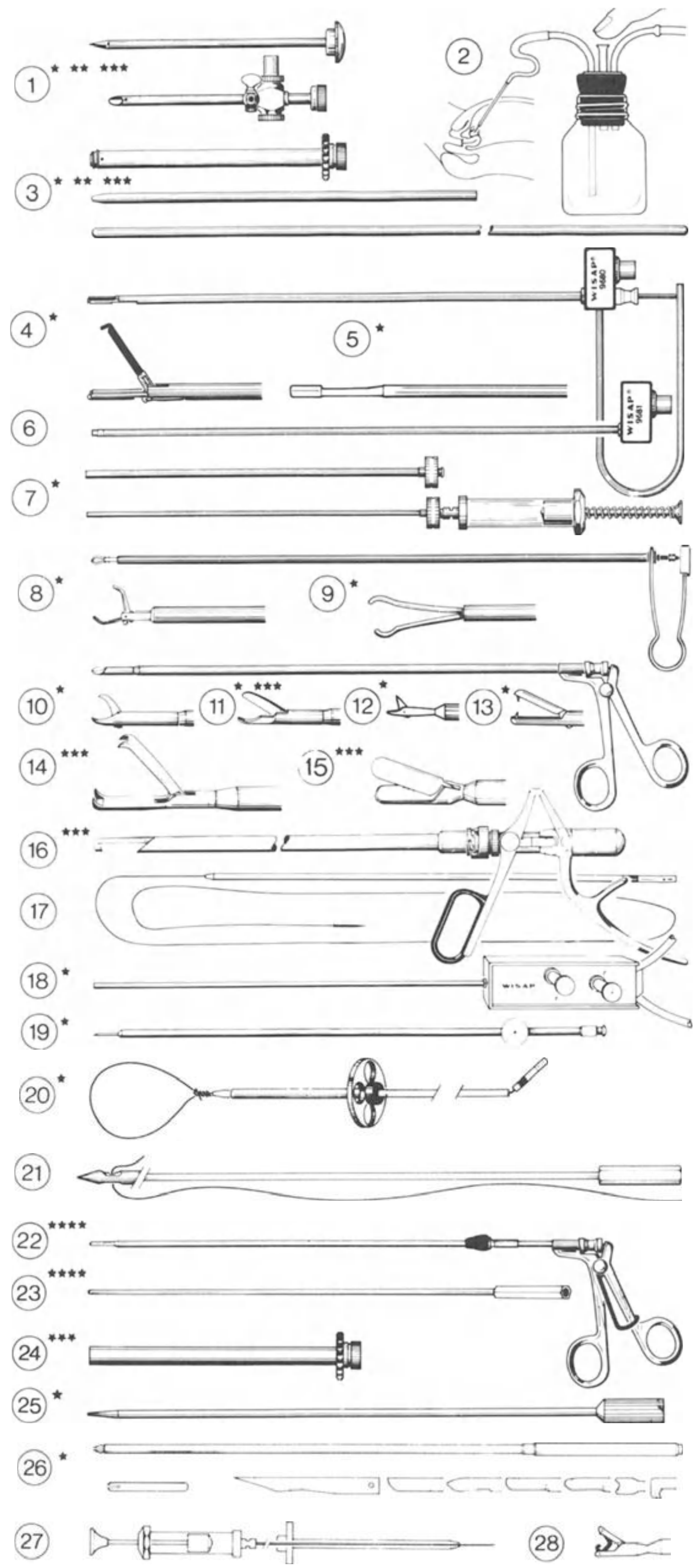
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FIGURE 1-22. Instruments for operative laparoscopy developed at the University of Kiel, Department of Obstetrics and Gynecology, over the years: (1) elliptically ground cone-shaped trocar; (2) suction bottle; (3) dilator set for atraumatic dilation; (4) crocodile clamp; (5) myoma enucleator; (6) point coagulator; (7) atraumatic palpator and suction tip; (8) atraumatic tube grasper; (9) atraumatic forceps; (10) hook scissors; (11) hollow-jawed scissors; (12) microscissors; (13) toothed biopsy forceps; (14) large claw-toothed forceps; (15) large spoon-shaped forceps; (16) morcellator; (17) endosuture; (18) monofil-bivalent suction and irrigation tube; (19) cyst aspiration cannula; (20) Roeder endoloop with applicator; (21) emergency needle; (22) needle holder; (23) suture knot director; (24) appendix extraction tube; (25) tubal sound; (26) microdissecting knife; (27) vasopressin applicator set; (28) clip applicator. (Reprinted from ref. 29, with permission.)

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2 Instrumentation

RONALD L. LEVINE

The ever-increasing number of instruments available to the surgeon with advanced gynecologic endoscopic skills continues to expand the horizon of pelviscopic surgery. The terms "operative laparoscopy" and "pelviscopic surgery" are all-encompassing designations for this approach to surgical laparoscopy. As stated in the preface, there is no concensus among the medical community in the United States concerning the use of terms for this type of endoscopic gynecologic surgery. This author, as well as many others, prefers the term pelviscopic surgery as a more descriptive designation. The term "pelviscopy" as noted in Chapter 1, was originally coined by Professor Kurt Semm. However, the terms operative laparoscopy and pelviscopic surgery are used in a broader context to apply to all advanced gynecologic endoscopic surgical procedures, including other modalities such as laser therapy.

As presented in other chapters, there are multiple advantages to operative laparoscopy, among which are less postoperative pain and morbidity and certainly decreased cost. This reduction has been reported to be almost 50%.[1] Moreover, the patient's rapid return to the work place and to normal activity has a marked economic impact (see Chap. 22).

As pelviscopic surgery emerges as a significant entity it becomes increasingly important for surgeons to compare results. The following section outlines a classification method that may facilitate future research and retrospective analysis.

Evaluation System

Category I

A. Dissection and lysis of pelvic adhesions necessitating more than two puncture sites
   1. Laparoscope plus two or more operative sites
   2. Lysis involves multiple cuts with the use of hemostasis (ligation or coagulation)
B. Ablation by fulguration, coagulation, or vaporization of endometrial implants using endocoagulation, electrocoagulation, or laser for implants that cover more than 1.5 cm in total area (treatment of stage I or II endometriosis—American Fertility Society Classification, see Table 2-1 and Table 18-2).

Category II

A. Resection of ovarian cysts by incising the capsule more than 1 cm (more than just needle aspiration) and removing tissue larger than 1 cm
B. Opening a hydrosalpinx by incision without involving suture or laser
C. Large adhesiolysis involving laser or more than one ligature.
D. Ablation by fulguration, coagulation or laser vaporization of large endometrial

THE AMERICAN FERTILITY SOCIETY CLASSIFICATION OF ADNEXAL ADHESIONS

Patient's Name ____________ Date ________ Chart # ________

Age ____ G ____ P ____ Sp Ab ____ VTP ____ Ectopic ____ Infertile Yes ____ No ____

Other Significant History (i.e. surgery, infection, etc.) ____________

____

HSG ________ Sonography ________ Photography ________ Laparoscopy ________ Laparotomy ________

	ADHESIONS	<1/3 Enclosure	1/3 - 2/3 Enclosure	>2/3 Enclosure
OVARY	R Filmy	1	2	4
	Dense	4	8	16
	L Filmy	1	2	4
	Dense	4	8	16
TUBE	R Filmy	1	2	4
	Dense	4*	8*	16
	L Filmy	1	2	4
	Dense	4*	8*	16

* If the fimbriated end of the fallopian tube is completely enclosed, change the point assignment to 16.

Prognostic Classification for Adnexal Adhesions

	LEFT		RIGHT
A. Minimal	________	0-5	________
B. Mild	________	6-10	________
C. Moderate	________	11-20	________
D. Severe	________	21-32	________

Treatment (Surgical Procedures): ____________

____

____

____

____

Prognosis for Conception & Subsequent Viable Infant**

________ Excellent (> 75%)

________ Good (50-75%)

________ Fair (25%-50%)

________ Poor (< 25%)

**Physician's judgment based upon adnexa with least amount of pathology.

Recommended Followup Treatment: ____________

____

____

Additional Findings: ____________

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DRAWING

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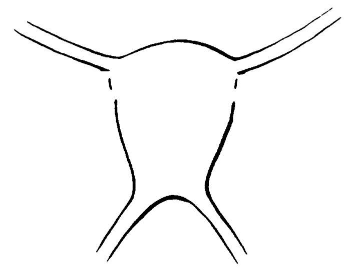

Property of
The American Fertility Society

For additional supply write to:
The American Fertility Society
2140 11th Avenue, South
Suite 200
Birmingham, Alabama 35205

From The American Fertility Society: The American Fertility Society classification of adnexal adhesions, distal tubal occlusion, tubal occlusion secondary to tubal ligation, tubal pregnancies, Mullerian anomalies and intrauterine adhesions. Fertil Steril 49:944, 1988. Reproduced with permission of the publisher, The American Fertility Society.

implants (stage III, according to American Fertility Society Classification)
E. Excision and removal of small amounts of tissue, i.e., hydatid cyst, using fewer than three ligatures or equivalent hemostasis

Category III
A. Adnexectomy (oophorectomy, salpingectomy, salpingo-oophorectomy)
B. Myomectomy (larger than 2.0 cm)
C. Removal of large amounts of tissue requiring the use of three or more ligatures or equivalent
D. Ectopic pregnancy surgery, either linear salpingostomy with removal of conceptus or salpingectomy (segmental or total)
E. Tubal surgery such as salpingostomy or salpingoplasty using either suture or laser
F. Adnexal surgery using endosuturing techniques
G. Treatment of pelvic abscess by drainage, irrigation and débridement of tissue (Reich technique[2])

Category IV
A. Aborted surgery-laparotomy due to:
   1. Difficulty beyond control by pelviscopic surgery
   2. Complication during surgery, i.e., severe bleeding, bowel injury, urinary tract injury
B. Diagnostic pelviscopic surgery
   After passing the laparoscope, pelviscopic surgery is found to be inappropriate

Many gynecologic surgical procedures, as presented in subsequent chapters, are amenable to the pelviscopic approach. The instruments required for pelviscopic surgery should be viewed in much the same manner as surgical instruments used for open laparotomy. All laparotomy sets have basic instruments that are found in almost any operating room. However, just as some of the instruments used for hysterectomy differ from those used for salpingostomy or oophorectomy, so it is for pelviscopic surgery. The basic instruments and sutures are discussed, but we also outline special surgical requirements. We do not review in depth the basic instruments and techniques used for standard diagnostic laparoscopic procedures, e.g., various uterine manipulators, light sources, or methods of insufflation, as they have been described in numerous papers, texts, and other chapters herein. Laparoscopes of all types have also been described.

Regardless of the equipment used, the cardinal rule governing the use of all instruments is that the operator should be as familiar with the instruments as a soldier is with a rifle. He or she should be able to take instruments apart and reassemble them and should be familiar with how they work and how they are cleaned and maintained. Unfortunately, many surgeons depend solely on the knowledge and training of operating room personnel to assemble and maintain these complex instruments. Perhaps the best trademark of the pelviscopic surgeon, aside from dexterity, is the ability to be a "gadgeteer" who feels competent to troubleshoot instrumentation problems. It is unavoidable, indeed inevitable, that occasional problems occur when using delicate and complex instruments. The best answer is to have back-up instruments for all key pieces, although this situation is often financially prohibitive.

Insufflation

The standard procedures used to produce a pneumoperitoneum have been noted by several authors.[3,4] Because pelviscopic cases are of relatively long duration and may involve cauterization, carbon dioxide is recommended over nitrous oxide as the insufflating agent. When monitoring end-tidal P_{CO_2}, blood pH, and CO_2 partial pressures, there have been no significant changes noted during normal general anesthetic ventilation. In all but the most obese patients, we use a standard 80-mm Verres needle to produce the pneumoperitoneum. The needle is placed through the umbilicus (rather than the ab-

FIGURE 2-1. High-flow insufflator. Important features of this type of equipment are the ability to maintain CO_2 flow of more than 4 L/min and to preset an insufflation pressure limit. This unit is electronic and monitors the true static intraabdominal pressure. (Courtesy of WISAP, Sauerlach, West Germany.)

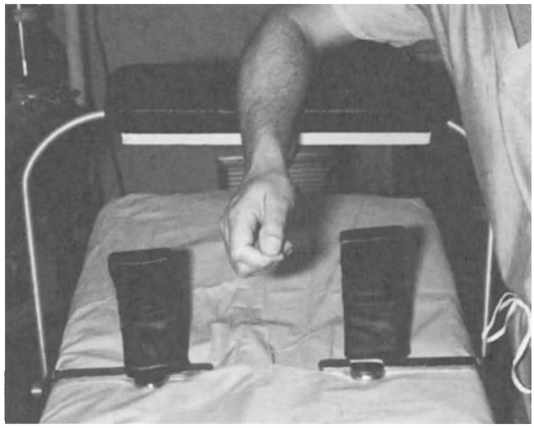

FIGURE 2-2. Position of a support bridge and shoulder braces. The bridge was made from an ether screen with a padded board fitted to the cross bar.

dominal wall) using standard laparoscopic techniques. This aspect of pelviscopic surgery is also addressed in Chapter 3.

It is of utmost importance to use a high flow insufflator. If the insufflator cannot supply, on demand, a gas flow of approximately 4 L/min or more, adequate visualization cannot be maintained. Multiple punctures and frequent instrument changes will result in a large loss of gas pressure unless high flow rates are available. For safety precautions, it is almost mandatory that the operator be able to preset the insufflator to limit the insufflation pressure to less than 15 mm Hg. In theory, this threshold should prevent possible collapse of the inferior vena cava and subsequent loss of venous return to the heart. The instruments best suited for high flow insufflation are the electronic insufflators (Fig. 2-1). This equipment continually monitors the pressure and should be able to reflect the true static intraabdominal pressure. Regardless of the insufflator used, it is important that CO_2 can be applied from an external as well as an internal tank. Insufflators that use only internal tanks of CO_2 limit the quantity of gas available and may require frequent pauses to refill the internal supply.

Patient Positioning

Most standard operating tables can be used for pelviscopic surgery. The table must allow placement in both Trendelenberg and Fowler positions. It must also accommodate stirrups and patient shoulder braces as well as a support bridge for the surgeon's arm. To operate for any length of time, the surgeon who is looking directly through the scope must lean on the support bridge (Fig. 2-2). Such bridges are available commercially, although they can easily be constructed from a common ether screen. A padded board can be fitted to the crossbar of the screen, thus serving the purpose of support. It is important that the bar be securely fastened to the table to prevent the surgeon from accidentally falling onto the patient (Fig. 2-3). However, it is becoming increasingly popular to work directly from the television monitor, which makes the bridge unnecessary. Many surgeons use a beam splitter that allows the surgeon to work with the screen for certain procedures or directly from the scope for others. For some procedures, e.g., fine dissection, tissue planes may be better visualized directly.

The patient's lower extremities must be

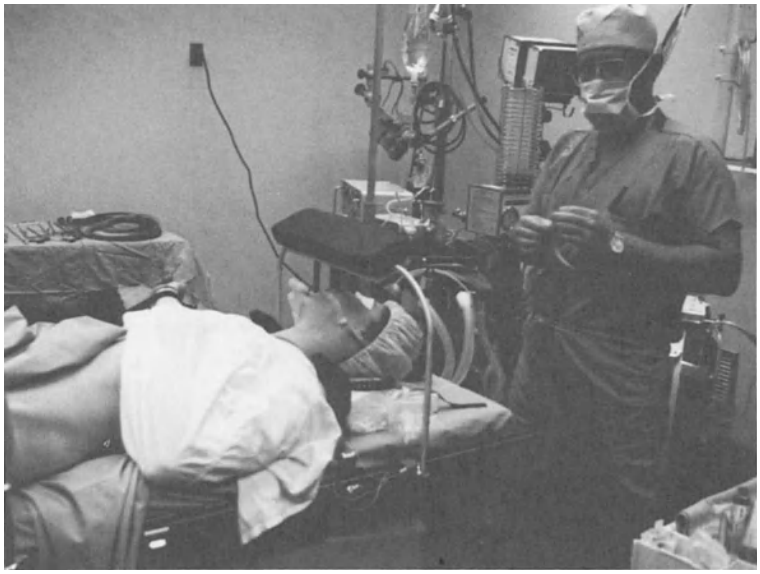

FIGURE 2-3. Shoulder braces and support bridge in place. The patient is being monitored with electrocardiogram leads and has an endotracheal tube in place.

properly placed in stirrups that provide adequate support but allow a proper amount of flexion of the thigh in relation to the trunk (Fig. 2-4). If the angle is too acute, it becomes impossible to manipulate the instruments properly from both sides (Fig. 2-5). An angle of about 145° allows adequate room for moving the instruments. If the angle is much less than 145°, the motion of the hairline puncture instruments is limited. The stirrups should be well padded to avoid compression of the popliteal nerve. The buttocks should extend slightly beyond the end of the table to allow full depression of the uterine manipulator to antevert the uterus. Patient preparation is covered in Chapter 3.

After placement of a uterine manipulator, it is advantageous to use a weight to antevert the uterus. A weight of approximately 350 g suffices to hold the uterus in position, thereby relieving an assistant from this task. The weights may be attached to a chain to drape over the manipulator or connected to a malleable wire (Fig. 2-6). Most pelviscopic surgeons stand or sit on the left side of the table, in which case the television

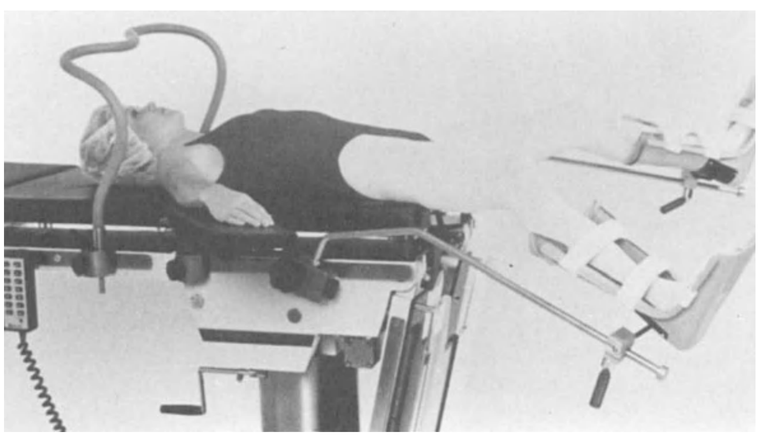

FIGURE 2-4. The Allen Universal stirrups are one type of padded stirrups that can be adjusted to allow good support to the lower extremity and still permit correct positioning. (Courtesy of Allen Medical Systems, Inc., Mayfield Heights, Ohio.)

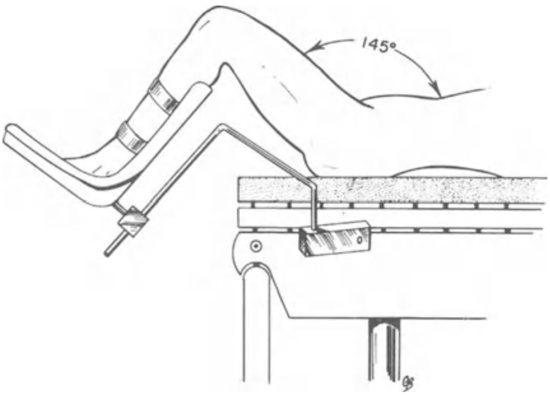

FIGURE 2-5. Angle between the thigh and trunk should be 145° or more, which allows maximum movement of the lower abdominal secondary instruments.

monitor, if used, must be placed either on the right side, or toward the foot of the table. It is advantageous to elevate the screen slightly above the line of sight rather than level with the table. Ideally, the operating room is equipped with two monitors—one at an angle best suited for the vision of the assistant and scrub technician and one for the surgeon (Fig. 2-7).

Shoulder braces are also imperative in pelviscopic surgery. Frequently, it is necessary for patients to be placed in the steep Trendelenberg position (more than 15°–20°) for a prolonged time. Without proper support, the patient may rapidly slide toward the anesthesiologist (Fig. 2-3). Padded shoulder braces must be placed with care over the acromion, keeping them as far lateral as possible to avoid compromising the neck. It is recommended that a space the width of a finger be allowed between the shoulder and the brace to avoid undue pressure on the skin over the acromion. Casual use of the shoulder brace may lead to nerve injury to the neck or shoulder.

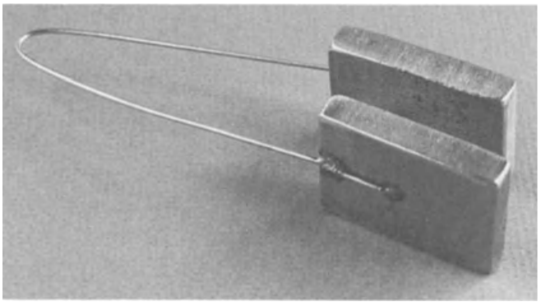

FIGURE 2-6. "Homemade" uterine manipulator weight made from malleable stainless steel wire and stainless steel weights. The total weight is 350 g. The weights can be draped over the end of the manipulator.

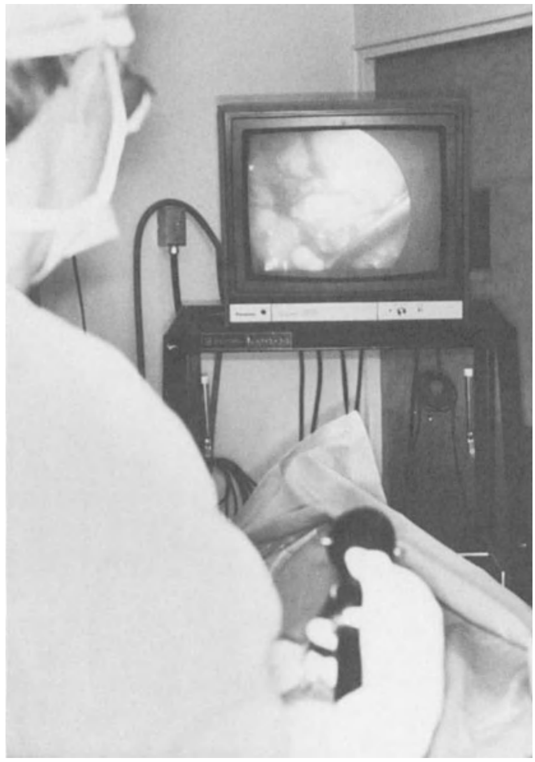

FIGURE 2-7. Television monitor is placed so the surgeon can look straight ahead at about eye level.

Optics

There has been considerable literature published on laparoscopy and laparoscopes, but some mention must be made regarding specific requirements for pelviscopic surgery. It is important that a true perspective is obtained with as large a panoramic view as possible, allowing the operator to coördinate

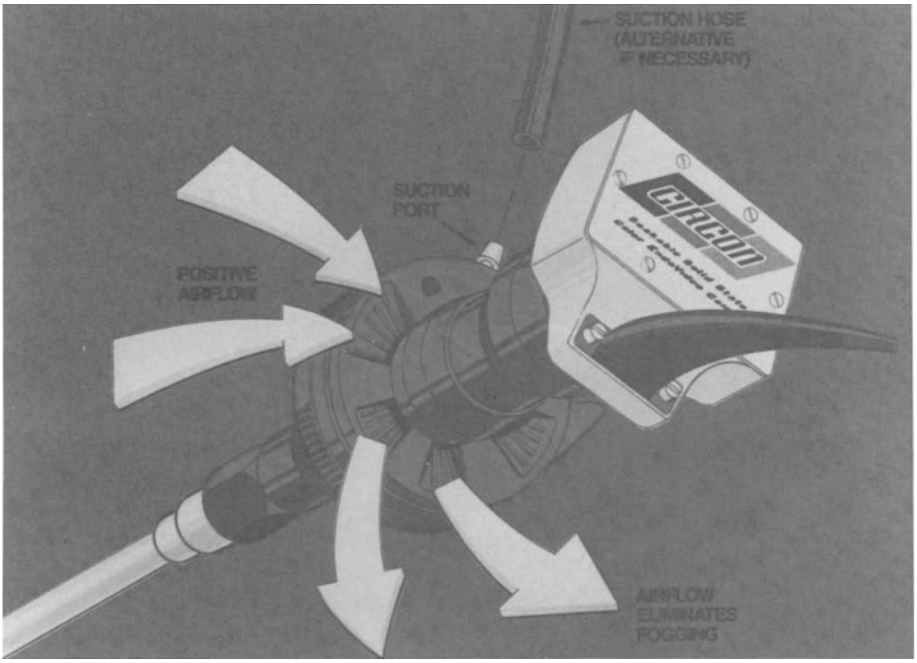

FIGURE 2-8. Connection of the video camera to the scope with an airflow attachment to eliminate fogging between the camera and the objective lens. (Courtesy of Circon ACMI, Stamford, Connecticut.)

the instruments properly, particularly for fine suturing or dissection. To obtain maximum resolution and imaging, we prefer a large scope—either 10 mm or 11 mm—with a visual angle of 0° (180°). The 0° scope allows the more natural "heads-on" approach, permitting the surgeon to use normal perspective. The large scope is best suited for either still or video display. We always encourage use of a television monitor for maximum participation of an assistant and scrub personnel.

The bottom line with use of the endoscope is the surgeon's ability to see. Therefore it is vital that fogging be prevented. Antifogging solutions (e.g., Antifog Agent, Wolfe Manufacturers, Chicago, IL) are recommended and should be applied prior to commencing surgery. A supply of warm sterile water or saline is always kept handy so the distal end of the scope can be placed in the warm solution and then reinserted into the abdomen. Alternatively, all experienced laparoscopists are familiar with the technique of touching the fogged end to a piece of omentum or uterus for rapid defogging. Fogging between the camera and the objective of the scope, which occurs at times, can be an annoying problem; however, the newer cameras have incorporated a number of methods to obviate this difficulty. One method uses airflow (Fig. 2-8) (Circon ACMI, Stamford, Connecticut), and another has developed a glass coupling interface using a sapphire system.

Instrument Cart

The instrument cart is positioned on the side of the table opposite from the surgeon. This cart holds all the electrical devices for pelviscopic surgery. By placing the cart on the opposite side, the surgeon is able to view all the dials. The basic equipment includes the insufflator, the light source, at least one

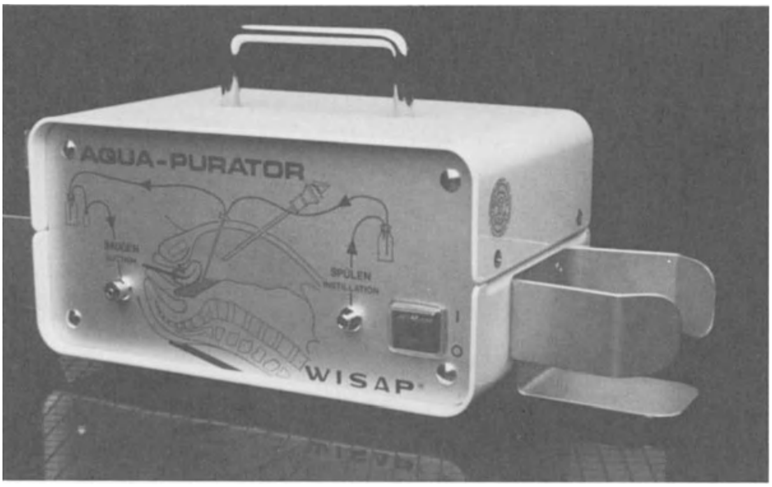

FIGURE 2-9. Aquapurator. It has two ports, one for irrigation and one for suction. The suction port can be bypassed to wall suction if desired. (Courtesy of WISAP, Sauerlach, West Germany.)

hemostatic source (endocoagulator or bipolar generator, but preferably both), and lastly the Aquapurator (Wisap, West Germany). Developed by Semm, the Aquapurator is an important addition to the armamentarium of the pelviscopic surgeon (Fig. 2-9). This instrument allows irrigation fluid to be instilled at a pressure of approximately 200 mm Hg and can also be used for aspirating fluid. The irrigation component is used frequently, but it is sometimes necessary to bypass the pump, using the standard wall suction in the operating room. Such versatility is especially useful in cases where large amounts of blood and clots require suctioning, as with a ruptured ectopic pregnancy. Warm Ringer's lactate solution is frequently used for irrigation. The standard 1-L bottle attaches quickly and easily to the side of the Aquapurator. At times the suction/irrigator can be used for "aquadissection" as described in Chapter 8.

FIGURE 2-10. Endocoagulator. The two dials control the temperature and the time of coagulation. The time may be shortened by removing the foot from the control pedal. (Courtesy of WISAP, Sauerlach, West Germany.)

The endocoagulator is another Semm innovation that uses direct heat in the range of 90°–120°C for hemostasis (Fig. 2-10; see also Fig. 1-7). The basic instrument is switched on and off with a foot pedal. The temperature and coagulation time may be preset. There is an acoustic musical tone that increases or decreases according to the temperature. The surgeon can then determine when the intraabdominal instrument is either hot or cool by listening to the tone. Although endocoagulation is used extensively, it is not used exclusively. Many laparoscopic surgeons in the United States still prefer bipolar and at times unipolar coagulation.

Entry

After insufflation, the instruments are placed beginning with the endoscope (see Chap. 3). As noted previously, entry through

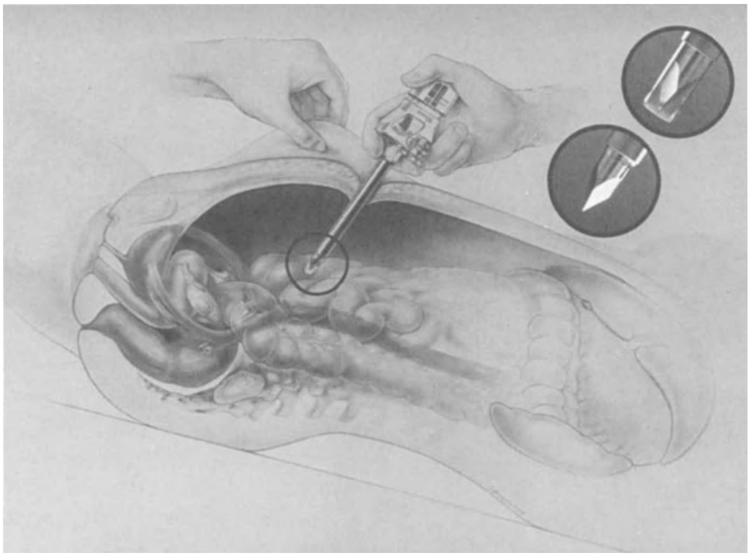

FIGURE 2-11. Disposable trocar with the covered tip. As the trocar is pushed through the abdominal wall, the covered sheath is pushed back. When the distended abdominal cavity is entered, the cover immediately springs into place over the sharp tip to protect against large blood vessel injury. (Reprinted with permission of United States Surgical Corporation, Norwalk, Connecticut.)

the lower umbilical fold via a vertical incision is usually preferred. Although this author primarily proceeds with a "blind entry," many surgeons prefer the "open laparoscopy" approach as described in Chapter 4. Some surgeons use the "blind approach" if there has been no previous surgery; however, if the patient has had prior abdominal surgery, "open laparoscopy" may be preferred, and Semm has described the "visually monitored peritoneal puncture" (see Chap. 1).

There is a continuing area of contention regarding the type of tip to use on the trocar. Some surgeons favor a pyramidal tip, whereas others extol the virtues of the conical tip, as discussed in Chapter 3. Each has advantages; however, the most important issue is sharpness. If the trocar is sharp, punctures are safer and easier regardless of the tip employed. It is the responsibility of the surgeon to check the sharpness of the trocars and ensure that they are on a scheduled sharpening program. The introduction of the disposable trocar and sheath (U.S. Surgical Corp., Norwalk, CT) obviates the problem by providing a sharp trocar. Another possible advantage to the disposable trocar is the built in safety shield that may protect against bowel injury (Fig. 2-11).

After the endoscope is in place, the secondary punctures are made under direct visual control in the pubic hairline, as described in Chapter 3. This author uses 5-mm trocar sleeves with trumpet valves for the secondary punctures. It is possible to use sleeves that have a flap valve, but they may lose more gas than the trumpet valve type. There are disposable sleeves that are also available for secondary 5-mm sites. However, as with all disposable products, the cost versus benefits must be considered. The complexity of the case determines how many secondary puncture sites are needed. Adnexectomy, cystectomy, myomectomy, and other complicated procedures are best performed with three or more operative punctures.

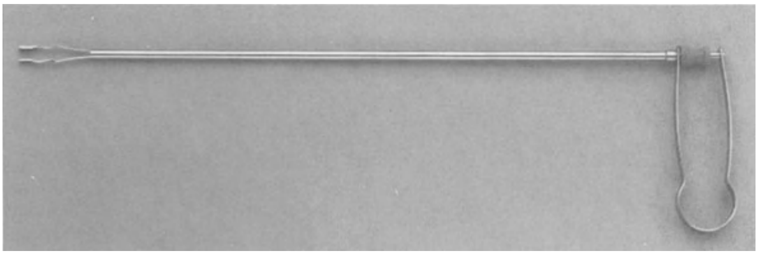

FIGURE 2-12. The 5-mm atraumatic grasping tongs. (Courtesy of Karl Storz Endoscopy–America, Inc.)

Operative Instruments

The instruments are described in groups according to their general usage.

Grasping

Small Instruments (5 mm)

Atraumatic grasping tongs may be used as the initial instrument of secondary entry allowing tissue to be grasped and moved with little risk of damage to the structures. The tongs allow the bowel to be displaced and held while another pair of atraumatic grasping tongs is used to mobilize the pelvic structures. A set with at least three atraumatic grasping tongs is recommended (Fig. 2-12). The atraumatic multiple-pronged grasper, such as that described in Chapter 4, is another useful instrument for grasping the ovary in an atraumatic fashion.

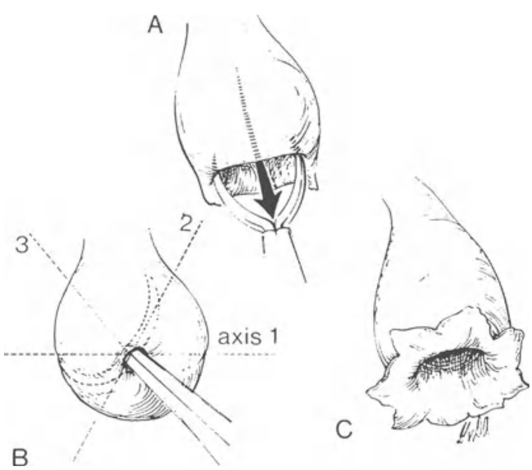

FIGURE 2-13. Atraumatic grasping forceps used for distal salpingostomy. The forceps are first inserted into the end of the tube (A) then opened and withdrawn (B) in three axis planes, thereby everting the edges (C). (Courtesy of Karl Storz Endoscopy–America, Inc.)

Atraumatic grasping forceps are used only for the most delicate grasping chore, i.e., tubal fimbria. This 5-mm instrument is used mainly for dilating the tube when performing a distal salpingostomy and must be handled with care, as the jaws can be easily sprung (Fig. 2-13).

Kleppinger forceps are usually employed for coagulation, although they also may be used as gentle grasping forceps. This instrument is used primarily for sterilization procedures but sometimes to coagulate an adhesion prior to cutting. Reich (see Chap. 5) uses these forceps for most hemostatic indications.[5] (Fig. 2-14).

Semm biopsy forceps are probably more appropriately called toothed forceps (Fig. 2-15). There is a small, sharp pin in each jaw of the forceps to ensure a firm grasp on the tissue. These forceps, or a similar 5-mm instrument, are an absolute necessity for pelviscopic surgery, and thus it is advisable to keep at least two available. This instrument is used to hold tissue tightly, especially if traction is needed. For example, when performing cystectomy, after the capsule is opened each side of the capsule can be held while the cyst wall is removed. The toothed forceps are also excellent for removing the cyst lining by means of a twisting technique that Semm described as a "curling iron" method.[6] These forceps are also used for subserosal myomectomy and can hold the serosa while a myoma enucleator is used to free the tissue (see Chap. 9).

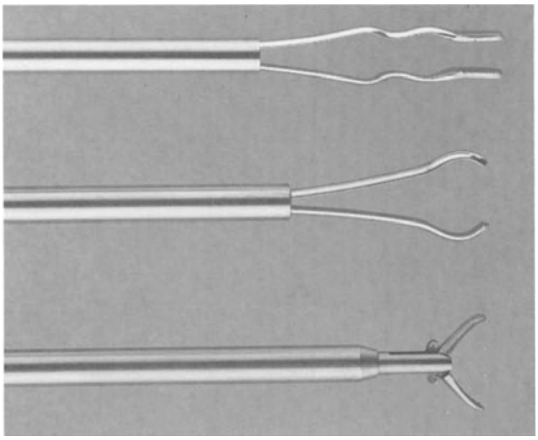

FIGURE 2-14. (Top) Kleppinger-type atraumatic forceps. (Middle) Semm atraumatic grasping tongs. (Bottom) Atraumatic grasping forceps also used for distal salpingostomy. (Courtesy of Karl Storz Endoscopy–America, Inc.)

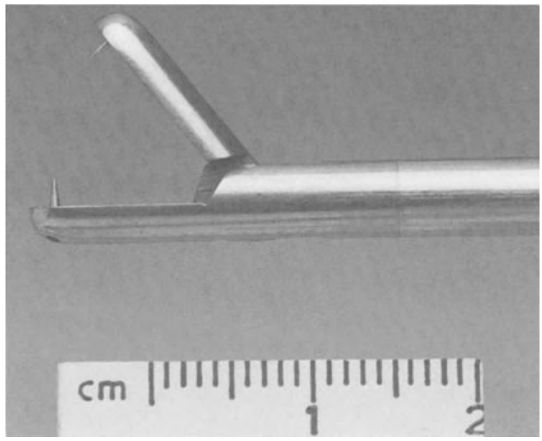

FIGURE 2-15. Toothed forceps, also called biopsy forceps. Because of the sharp pin at the end of each jaw, this 5-mm instrument is excellent for holding tissue on traction. (Courtesy of Karl Storz Endoscopy–America, Inc.)

Large Instruments (10–11 mm)

Large claw forceps are useful for grasping ample pieces of tissue, either for removal through an 11-mm sheath or for holding avascular tissue in order to place ligatures. These forceps can apply a twisting compression technique, allowing removal of large amounts of tissue through the sleeve without use of a morcellator (Fig. 2-16). This instrument is potentially dangerous because of the large sharp teeth that can inadvertently snag a piece of omentum or bowel. Claw forceps are particularly useful for myomectomy enabling the operator to grasp and exert traction on the myoma (see Chap. 10).

The spoon forceps have become a highly favored instrument because of their unique

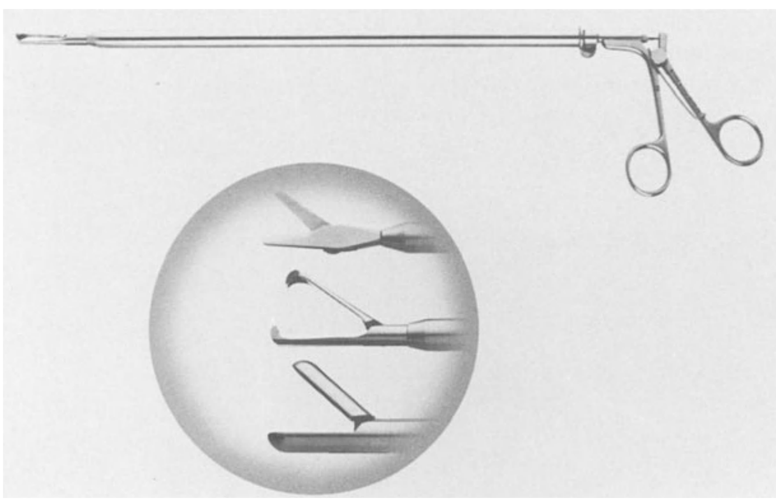

FIGURE 2-16. Large grasping forceps (fit through an 11-mm sheath). The inset shows the ends of three instruments. (Top) Large peritoneal scissors. (Middle) Large grasping forceps. (Bottom) Spoon forceps. (Courtesy of Karl Storz Endoscopy–America, Inc.)

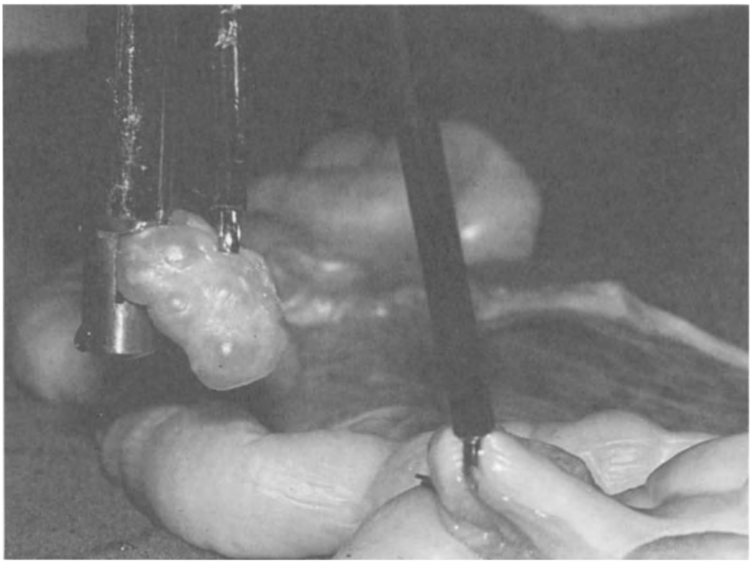

FIGURE 2-17. Technique of morcellation.

ability to easily remove blood clots and friable tissue. They are useful for surgery on ectopic pregnancies, whether for conservative salpingostomy or salpingectomy. In addition, spoon forceps can be used for excising dermoid cysts, although removal of the intact cyst through a colpotomy incision is preferred. Spoon forceps are safer than claw forceps because they do not have sharp teeth.

Morcellation

Several techniques can be used to remove a large amount of tissue from the peritoneal cavity. One may employ the twisting compression technique if the tissue is rather loose and compressible. However, if the tissue is bulky, as is found with an intact ovary or a large myoma, it must be removed by either colpotomy incision or morcellation. The *morcellator* ("tissue puncher"), another ingenious instrument developed by Semm (see Fig. 1-12), works by cutting pieces of tissue with its "biting" end (Fig. 2-17). When the handle is released, these small pieces of tissue are pushed up the storage tube. A large amount of tissue can be dissected and removed in this manner. Although this procedure can be long, cumbersome, and tiring, it is one of the few alternatives to colpotomy. Other options include "dicing" the tissue with either mechanical means or a laser, fol-

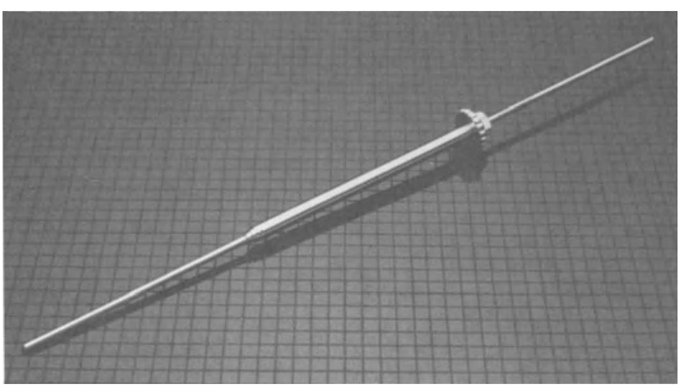

FIGURE 2-18. Dilator set. The solid rod is used as a guide and is placed through the dilator assembly. The entire assembly is placed through an 11-mm sheath. (Courtesy of Karl Storz Endoscopy–America, Inc.)

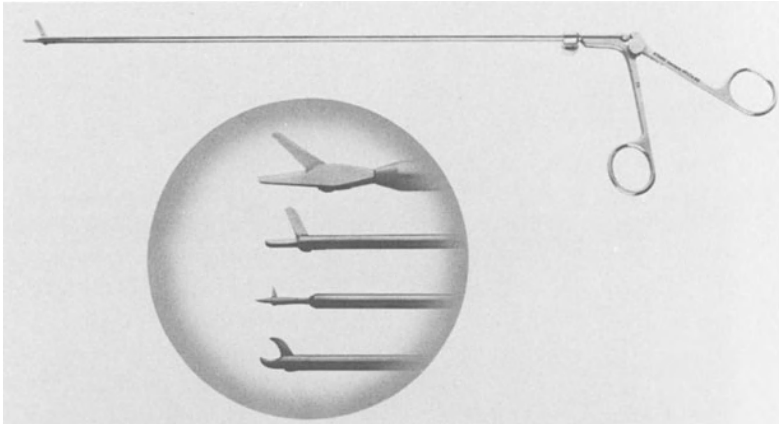

FIGURE 2-19. Cutting instruments. Inset: (Top) Large scissors, 10.5 mm. (2nd) Peritoneal scissors, 5 mm. (3rd) Microscissors, 5 mm. (Bottom) Hook scissors, 5 mm. (Courtesy of Karl Storz Endoscopy–America, Inc.)

lowed by removal using standard methods. A colpotomy incision may be used for removing large amounts of tissue as well as ovarian cysts and dermoids without rupturing them within the peritoneal cavity. The technique is outlined in Chapter 3.

The large instruments described here are introduced into the peritoneal cavity through an 11-mm sleeve. All surgery is initiated with 5-mm puncture sites; however, if a large instrument is needed, a 5-mm site is dilated to 11 mm using the Heinkel-Semm dilation instruments. With these instruments, a 5-mm cannula can be exchanged easily for an 11-mm cannula without making an additional puncture. A solid guide rod is placed through the 5-mm cannula. The cannula is then withdrawn, leaving the rod as a guide. The skin incision is enlarged slightly with a No. 11 scalpel. The dilator assembly is then placed over the rod and, by means of pressure while turning, uses the threads to screw the 11-mm sheath into the abdomen. The rod and threaded tube are removed, leaving the 11-mm cannula in place (Fig. 2-18).

The 5-mm *hook scissors* are the standard instrument for most cutting chores. They are the "Mayo scissors of pelviscopic surgery" and are used for cutting tissue such as adhesions or ovarian capsules, as well as for cutting suture material (Fig. 2-19; see also Fig. 1-5).

If fine dissection is required, as for adhesions close to bowel or for a fimbrioplasty, *microscissors* are excellent to have on hand. These scissors, however, are fine instruments with exceedingly sharp points. They must be handled with great care, not only to prevent damage to the points but also to protect the viscera. They must be passed through the 5-mm trocar sleeve only under direct vision (Fig. 2-20). *Straight scissors,* also called peritoneal scissors, are available for heavy cutting (insert, Fig. 2-19).

Biopsy punch forceps are used through the 5-mm site in their traditional way. A biopsy

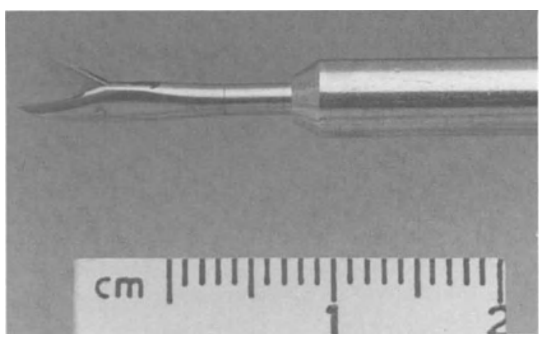

FIGURE 2-20. End of the microscissors. (Courtesy of Karl Storz Endoscopy–America, Inc.)

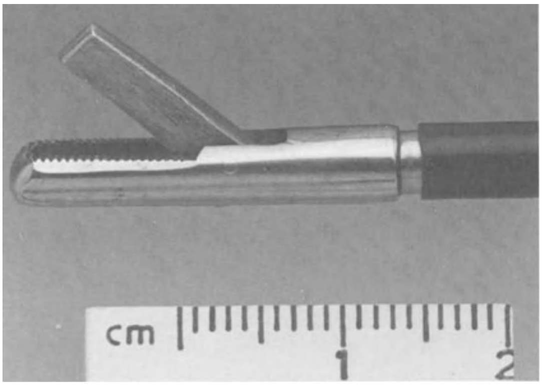

FIGURE 2-21. Biopsy punch forceps, 5 mm. (Courtesy of Karl Storz Endoscopy–America, Inc.)

may be performed for endometriotic lesions or any suspicious lesion encountered during surgery that is to be sent for frozen section or permanent blocks (Fig. 2-21). Several authors employ the *unipolar knife,* which may be used through a 5-mm sheath for delicate and controlled cutting at a low-power cutting current (see Chap. 5).

Hemostasis

The technique of laparoscopic hemostasis is discussed in Chapter 3. However, with respect to instrumentation, most American gynecologists recommend using bipolar or unipolar coagulation. Although bipolar coagulation is considered the safer modality, there are many who still use unipolar coagulation in a safe manner. Kleppinger forceps are the preferred instrument for sterilization and occasionally for hemostasis on omental adhesions.

The base unit for endocoagulation has been described previously. The intraperitoneal instruments used through 5-mm sheaths are the point endocoagulator, crocodile forceps, and myoma enucleator (Fig. 2-22; see also Fig. 1-7). The point endocoagulator is used to coagulate the stumps of pedicles and to develop hemostatic areas that are required when incising a tube for salpingostomy during tubal ectopic surgery. This instrument is used for treatment of endometriosis by coagulating endometrial implants with the application of direct heat. It may also be used for "ablating" the inside of benign ovarian cysts. The myoma enucleator is a broad-blade "hot knife" and is used primarily for myomectomy surgery (see Chap. 10). The crocodile forceps are used mainly to grasp and coagulate adhesions but sometimes also for obtaining hemostasis on pedicles. When resecting an ovarian cyst,

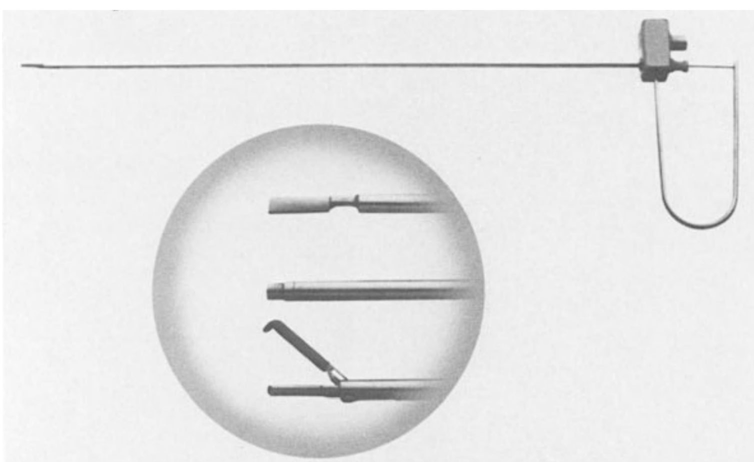

FIGURE 2-22. Endocoagulation instruments. Inset: (Top) Myoma enucleator. (Middle) Point endocoagulator. (Bottom) Crocodile grasping endocoagulation forceps. (Courtesy of Karl Storz Endoscopy–America, Inc.)

FIGURE 2-23. Magnified view of the knot used in the Endoloop. (Courtesy of Ethicon Inc., Somerville, New Jersey.)

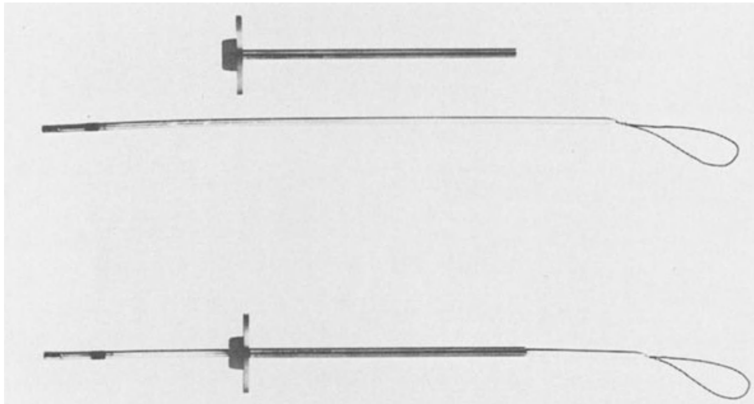

FIGURE 2-24. Endoloop and applicator. The ligature is loaded into the applicator and is then inserted through a 5-mm cannula. (Courtesy of Ethicon, Inc., Somerville, New Jersey.)

the surgeon may use the crocodile forceps to maintain hemostasis from the edge of the ovarian capsule. Semm has stated that adhesions are decreased by using endocoagulation rather than electrocautery[7]; however, there are no controlled studies available to confirm his statement.

The loop ligature is an excellent method for selective hemostasis. Originally described as the Roeder loop and used for tonsillectomy, it was developed by Semm and is now available as the Endoloop (Ethicon, Somerville, NJ). The Endoloop is presently available as 0-chromic, and 4-0 plain catgut. The ligature is preformed into a loop using a "fisherman's knot" (Fig. 2-23). The free end of the ligature traverses a plastic guide and is embedded into a plastic end-piece. The ligature is loaded into a tube called an applicator, which is then placed through a 5-mm cannula (Fig. 2-24; see also Fig. 1-9). The loop is then extruded into the abdomen and placed over the pedicle or tissue that is to be ligated. The knot is set with the plastic guide by pulling on the free end while pushing the plastic guide down against the knot. Tensile strength studies at the University of Louisville have shown the importance of one or at most two pushes of the plastic guide.[8] If more "tugs" are made the knot strength decreases (Table 2-2). This procedure is preferred for oophorectomy, salpingectomy, and ligating bleeders. When performing an oophorectomy, three ligatures are used as described by Semm and Mettler[9–11] (Fig. 2-25). Salpingectomy also requires two or three ligatures for complete security. At times it is difficult to slip the loop over large pieces of tissue, in which case a knot guide is used. It is easily made by cutting a large notch into the end of a laparoscopic probe (Fig. 2-26).

If a loop cannot be used and suture is needed either to close a capsule or perhaps create a cuff salpingostomy, a suture with a swaged-on straight needle is used. Endosu-

TABLE 2-2. Tensile testing of the PLL[8]

Regimen	Failure load (kg)
PLL—single pull	1.36 ± 0.25
PLL—two pulls	1.21 ± 0.21
PLL—three pulls	0.60 ± 0.40
Chromic gut suture	1.43 ± 0.12
Suture-tail junction	1.46 ± 0.11

PLL = pelviscopic loop ligature
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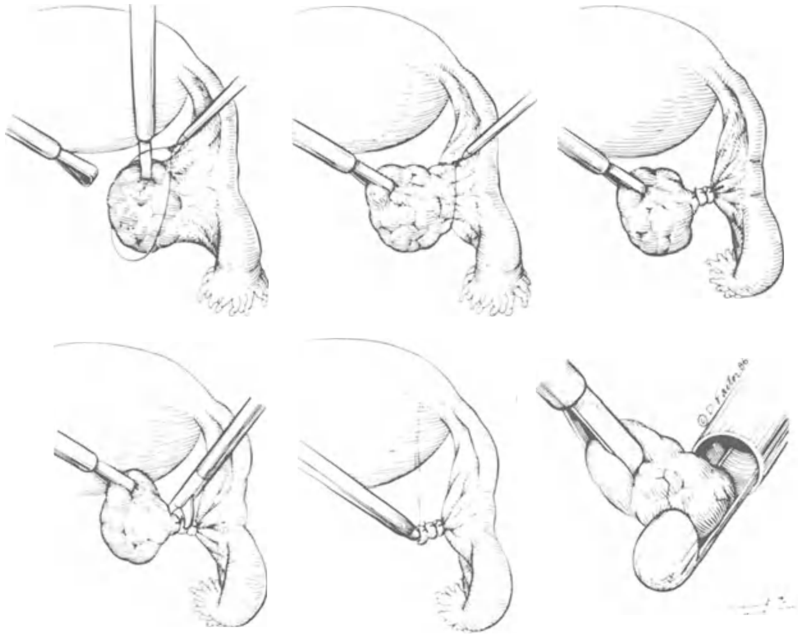

FIGURE 2-25. Oophorectomy using the three-ligature technique. After the ligatures are applied, the ovary is cut free, the stump is endocoagulated, and the tissue is morcellated. (Courtesy of David A. Factor.)

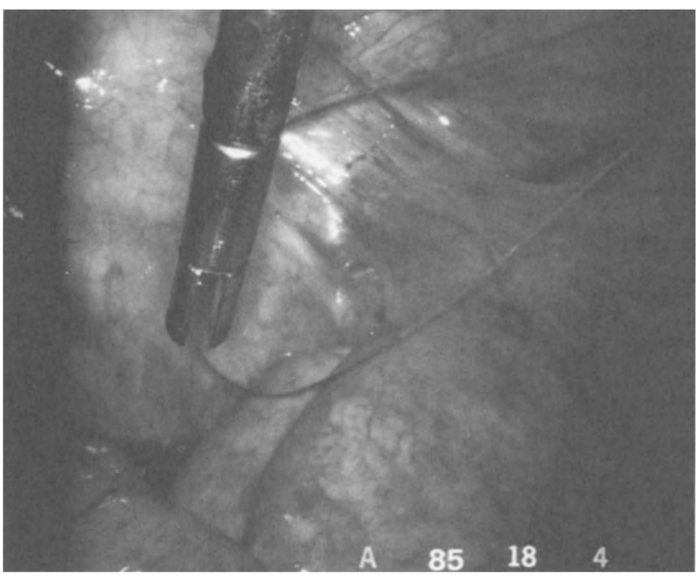

FIGURE 2-26. Knot guide may be used to push the loop ligature into place. Here the ligature is being guided over an ovary.

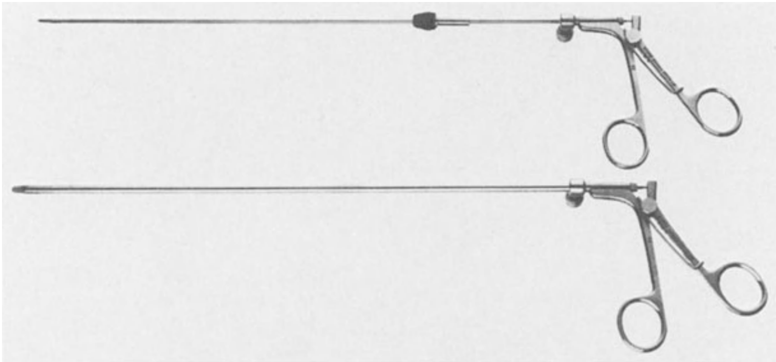

FIGURE 2-27. (Top) A 3-mm needle holder. Note the sliding rubber stop used to prevent gas loss when the instrument is placed through the applicator. (Bottom) A 5-mm needle holder. (Courtesy of Karl Storz Endoscopy–America, Inc.)

ture is commercially available for any surgical procedure in which chromic catgut can be used. However, most surgeons prefer not to use chromic catgut for tubal surgery. The suture most frequently used is similar to the Endoloop but has a 3-cm straight needle swaged on. The suture is used with 3-mm and 5-mm needle holders (Fig. 2-27). The suture is passed into the abdomen through the applicator with the 3-mm needle holder. The needle is then picked up with the 5-mm needle holder, and the tissue is sutured. The needle is brought out of the body with the 3-mm holder. An external "fisherman's knot" is made, and the knot is pushed into place with the plastic guide. If a fine suture is needed, either 4-0 polydioxanone (PDS; Ethicon) or 4-0 polygalactic AKD (Vicryl; Ethicon) that has a swaged-on needle is used, and an intraabdominal knot is formed. This technique, however, is much more difficult to master than the extracorporal knot tie. It is also possible to perform a ligature tie by the method of Reich and McGlynn[2] (Fig. 2-28).

Irrigation

The Aquapurator was described earlier; the intraabdominal part is a simple but efficient instrument called an irrigation/aspiration cannula (Fig. 2-29; see also Fig. 1-13). This apparatus is another significant Semm contribution. It is simply a single 5-mm tube that has a Y connection to the plastic tubes that join the Aquapurator or wall suction (or both). When either aspiration or irrigation is desired, it can be controlled by two spring-loaded buttons, which allows one-hand rapid, simple suction/irrigation. Chapter 3 describes the techniques of peritoneal lavage. Suction irrigation and water dissection equipment for operative laparoscopy is discussed in Chapter 15.

Summary

There are now many instruments that have been developed by various instrument companies and individual surgeons that have contributed to the advancement of pelviscopic surgery. A relatively basic collection of materials and equipment necessary to carry out pelviscopic surgery or operative laparoscopy has been described. Instruments used for laser surgery are thoroughly described in Chapters 12–16. New instruments are continually being developed that will enhance safe and versatile endoscopic procedures.

In the near future we will have available some innovative instruments that will allow safe, sure endoscopic hemostasis. Two new instruments are being developed by the U.S. Surgical Corporation (Norwalk, CT) that

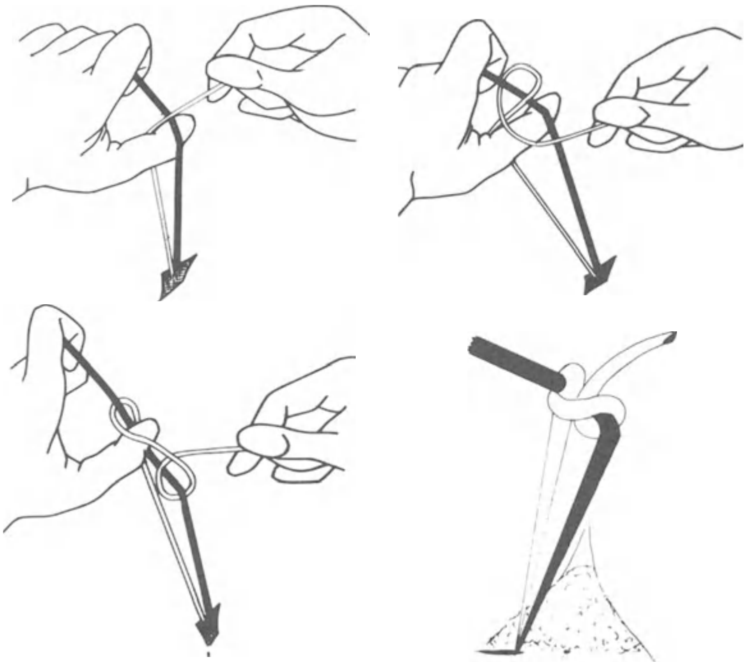

FIGURE 2-28. External knot as described by Reich and McGlynn.[2] It is tied as shown and then slipped back in by traction. Hemostasis cannot be achieved with this knot which is used only to approximate tissue. (Reprinted from The Journal of Reproductive Medicine, ref. 2, with permission.)

may allow many endoscopic procedures to be performed readily. The first is a fully automatic clip applier. The clip is large enough to allow the pelviscopic surgeon to control moderate-size blood vessels. It is composed of a titanium material, similar to clips that are presently available for general surgical techniques. This clip applier passes through a 10-mm sheath. The second instrument is a stapling device similar to the GIA instrument used to transect and anastomose tissue. The new instrument passes through the 10-mm sheath and places six rows of staggered vascular staples while a knife blade simultaneously divides the tissue. The staples hemostatically seal each side of the divided tissue. The end result is a 30-mm staple line. With this control, one can easily ligate and divide the infundibulopelvic ligament and even conceivably the uterine vessels and broad ligament. The application of these pioneering instruments and others on the horizon will open many new avenues for endoscopic surgery.

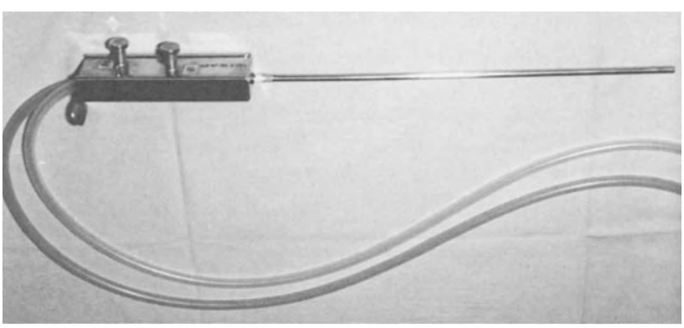

FIGURE 2-29. Irrigation/aspiration cannula is controlled by pushing the spring-loaded buttons. The tube fits through a 5-mm cannula. (Courtesy of Karl Storz Endoscopy–America, Inc.)

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3
Techniques

JOHN M. LEVENTHAL

> There is only one good, knowledge, and one evil, ignorance.
>
> SOCRATES

The history of pelviscopic surgery is well documented in Chapter 1 by Professor Kurt Semm, who is almost solely responsible for the introduction and early development of this field.[1] As presented in Chapter 2, the increasing application of these techniques, known variously as operative laparoscopy, advanced laparoscopic surgery, extended laparoscopic surgery, and particularly in Germany as "pelviscopy," has inspired significant rethinking of the appropriate surgical approach to many problems previously thought to be amenable only to open surgery,[2,3,4] particularly with respect to procedures involving infertility in women. It is in this group of patients that the term pelviscopic surgery is perhaps most appropriate, but it is essential to a full understanding of these modern techniques that the reader appreciate that advanced operative laparoscopic surgery is not confined, as its more limited synonym might imply, to the pelvis. An increasing number of procedures above the pelvic brim, in both men and women, have been described that constitute appropriate additions to the list of applications of these procedures. In this chapter we discuss the principles of operative gynecologic endoscopy, training of the operative laparoscopist, techniques common to the most frequently performed pelviscopic procedures, and finally the advantages advanced laparoscopy appears to offer over open surgery. As stated in the Preface, there is presently no concensus among the American medical community regarding the use of terms for this type of endoscopic gynecologic surgery. This author, as well as many others, favors the term pelviscopic surgery, and this designation is used in this chapter as well as Chapters 9 and 11. The specific techniques of this surgery required for specialized applications are covered in greater detail in subsequent chapters.

Principles

As common sense dictates, the principles that form the basis of pelviscopic surgery are no different from those that apply to any form of abdominal surgery. Good surgical technique is, after all, basic to any procedure, and the surgeon must at all times be uncompromising in its application. During pelviscopic surgery, for example, attention to hemostasis, care in the handling of tissue, accurate knowledge of both normal and pathologic anatomy, and the identification of various disease states are no more or less important than they are at open surgery. The experience and skill the prudent surgeon develops at laparotomy must indeed be conveyed in exactly the same measure to endoscopic surgery.

The development of proficiency and skill for advanced laparoscopy is an evolutionary process that depends and builds on the acquired skills of the surgeon in many areas of surgery. Perhaps the most obvious are skill and confidence in the techniques of basic laparoscopy, but good surgical judgment in general remains the cornerstone of all successful surgery. The demands of the more extensive tissue and instrument manipulation in the "closed" environment of pelviscopic surgery require a finely tuned sense of clinical judgment with respect to the *limitations* as well as the possibilities of the procedure. The specificity of this judgment is probably not intuitive but must be developed with advancing experience in each of the specific pelviscopic procedures. In this respect, pelviscopic surgery or operative laparoscopy is no different from any other surgical technique. However, from the outset it must be appreciated that, in other respects, some significant differences do exist. Perhaps principal among them is the necessity to manipulate tissue with *instruments alone.* It takes considerable experience to become accustomed to accurate perception without the direct tactile sense and tissue handling available at open surgery. The experienced diagnostic laparoscopist has of course developed this sense of "instrument tactility" to some degree and is able to bring this valuable knowledge to the learning of the more complex procedures involved in this surgery, including extirpation, destruction, and repair of tissue and organs. In addition to those basic tenets of surgery applicable to all operative procedures, however, there are some principles of technique that have particular significance for pelviscopic surgery.

Visualization

There is a subtle but important distinction between adequate visualization and adequate exposure. The distinction is more or less obvious at laparotomy where it is possible to visually evaluate areas of the abdomen which the limitations of the chosen incision place outside the possibility of surgical manipulation. However, at pelviscopic surgery this distinction is less apparent. If the critical placement of the laparoscope and secondary puncture sites is correct, it is usually possible to surgically manipulate tissue in virtually all areas visualized. Although the subject is discussed in greater detail in connection with specific procedures, this distinction must be considered one of the advantages offered by the endoscopic approach.

Visualization of the tissues and organs of the pelvis and upper abdomen as well as of pathologic states existing in those organs has some additional importance for pelviscopic surgery. In the absence of the direct sense of touch, the experienced pelviscopist must rely heavily on the appearance of the tissues and organs visualized. The correlation between appearance and function is of course based on the overall experience of the surgeon, not only at open surgery but at laparoscopy as well. This dependence on experience further underscores the importance of prior training and acquired competence.

Instrumentation

As discussed in Chapter 2, there are few areas of surgery that require greater attention to the instrumentation used for the procedures undertaken than that of pelviscopic surgery. It goes without saying that, apart from the health and condition of the patient and the experience of the surgeon, the availability of the proper instruments determines the extent and type of surgery that can be safely performed. As noted in Chapter 2, a wide variety of rather special instruments and equipment must be available and in good working order (see Fig. 1-22). Inasmuch as proficiency implies familiarity, it is appropriate to say that the surgeon, to be considered qualified in pelviscopic surgery, should be thoroughly "comfortable" with the use of all of these specialized instruments.

Training

The training of the surgeon in any operative technique is a process involving a number of important factors, chief among which is the overall surgical experience he or she brings to learning the new procedure. Both innate and acquired manual dexterity are probably characteristic of every surgeon. However, the endoscopist, because of the impossibility of handling tissues directly, is required to have an especially well developed dexterity with instruments. The dexterity must be even more finely developed by the operative laparoscopist, who must learn to utilize a bewildering array of instrumentation for intricate manipulation and frequently precise removal and repair of tissues. Adroitness is only a part of the picture, however; judgment is equally, if not much more, important. With all surgery, and certainly with endoscopic surgery, when to operate, when not to operate, and when to stop operating are as important as how to operate. The procedures encompassed by endoscopy, like those of all surgery, require the surgeon to have more than the mechanical ability to position the patient and manipulate the operating instruments. They demand a constantly prepared and observant mind secure in the knowledge, and alert to the multitude of pathophysiologic possibilities, of the pelvis as observed through the laparoscope. The knowledge must come first-hand, acquired mainly with hands-on experience with the instruments and an eye at the laparoscope. The training of the laparoscopist must indeed be evolutionary and place great emphasis on prior laparoscopic experience.

The acquisition of skill in operative endoscopy is therefore a process that begins with skill as a surgeon. Such a statement is intended to emphasize an important point but is not helpful for the surgeon in quest of training in advanced operative laparoscopy. There are an increasing number of short courses in operative laparoscopy or pelviscopic surgery being offered throughout the world. Many are nothing more than didactic lectures illustrated with color slides or videotapes, a few of which have been made by the lecturers and most of which have been borrowed from the relatively few experts in the field. They are of little value to the earnest student and are perhaps detrimental to both the surgeon and the prospective patient in the sense that they may leave the registrant with the illusion that the course has bestowed an expertise that in fact does not exist. Other courses, taught by accomplished laparoscopists and offering sufficient hours of hands-on experience with training models or tissue to allow the student to begin to acquire truly new skills, represent the type of training that should be sought by those with genuine interest and realistic aspirations. The student should return from such a course resolved to employ his or her newly learned techniques only on training models until truly comfortable enough with the basic skills required to ensure the patient's well being. Adequate training in operative endoscopy is therefore, in every sense, postgraduate in nature. As the minimum requirement, the surgeon wishing to become proficient in these procedures should bring to the learning experience an exceptional ability in laparoscopy. However, pelviscopic surgery is not merely an extension of laparoscopy. Moreover, just as radical hysterectomy with pelvic lymph node dissection is not for every gynecologic surgeon, *operative laparoscopy* or *pelviscopic surgery is not for everyone*. It is sometimes difficult to resist the temptation of new techniques, and we surgeons are seldom in short supply of ego. However, pelviscopic surgery calls for honest self-appraisal of one's true interests and abilities. Thoughtful consideration in this regard generally results in the appropriate choice for any individual and goes far to ensure the best care for the prospective patient.

Technique and Preparation

It is not our purpose to describe in detail the techniques involved in this surgical procedure, as many are described in later chapters. There are, however, some basic techniques that are common to most procedures, and it is these techniques that form the basis of this part of the chapter.

It cannot be overemphasized that the first, and critical, focus of any gynecological endoscopic procedure is preoperative preparation. In a discussion of this important phase of technique, we have found it useful to think of preparation as applying to three general areas: the surgeon, the patient, and the operating room.

Preparation of the Surgeon

Preparation of the surgeon for operative laparoscopy is as important as preparation of the patient and starts with specific and detailed knowledge of the patient and his or her condition. Well prior to surgery, a detailed history should be evaluated with a trained mental distillation of the pertinent information. This step ensures that most conditions can be anticipated to some degree and objectively examined so that appropriate endoscopic treatment can be performed. At the moment of the first view through the laparoscope in any particular case, all of the prior training, experience, and preoperative preparation of the surgeon must come together to achieve the best possible understanding of the patient's problem, to select the best surgical approach to its solution, and finally to accomplish the procedure in the most skillful and professional manner. Only when this approach is consistently accomplished with confidence and organization can the endoscopic surgeon be considered adequately trained.

The reader may be somewhat surprised to be asked to consider "preparation" of the surgeon as a part of the technique of a surgical procedure. On closer consideration, however, there would probably be universal agreement that this aspect, usually taken for granted, is perhaps the most important. Considerably more than the mechanical ability to position the patient and manipulate the instruments is demanded of all surgeons and certainly no less so for the laparoscopist. In fact, the "closed" environment of pelviscopic surgery makes an especially stringent demand on the surgeon to have a keen eye and a well prepared mind. First, an accurate history is critically important. It is greatly preferred that the laparoscopist personally take a complete history of the patient and devote sufficient time to its review to possess a thorough understanding of the problems presented and the implications they may have for the proposed endoscopic procedure. In this regard, there must be adequate time devoted to studying prior laboratory data, notes, operative dictations, visual documents of previous operative procedures if available, radiographs, and any sonographic or radiologic diagnostic studies that have been conducted. It should be remembered that conditions existing in the pelvis or abdomen may well have been overlooked by previous surgeons or may have arisen since the time of the prior operation. The endoscopic surgeon who is completely prepared and experienced not only is equipped to deal technically with the surgical procedure but also is unlikely to miss minimal or obscure conditions that are important, and sometimes critical, to the overall management of the patient.

The prepared laparoscopist is the best laparoscopist—a basic principle of endoscopic surgery that cannot be overemphasized. At least two implications should be evident. First, the surgeon desiring to perform extensive endoscopic surgery is operating at a level of technical skill not generally demanded of the diagnostic laparoscopist; therefore he or she must have achieved significant expertise in all of the operative techniques required before attempting any such procedure. The patient deserves nothing less. Second, it should not need stating that the laparoscopist *must* be the primary surgeon. The practice of "turning" cases to the less experienced cannot be supported in the case of advanced operative laparoscopy. The student must spend many hours using the pelviscopic trainer and nonvital tissue before bringing his or her newly acquired skill to the operating table. After this preparation, more hours of direct observation and minimal manipulation under the close supervision of the experienced laparoscopist must go into "preparation" of the surgeon.

Preoperative Preparation of the Patient

As with any proposed surgical procedure, the first step is to discuss the procedure with the patient. It is essential not only for the medicolegal considerations of present-day practice (see Chap. 22) but, more importantly, so the patient has a thorough understanding of exactly what the surgeon wishes to accomplish. It is particularly important to the proper and adequate preparation of the patient that explanation of the proposed surgery include discussion of the overall condition, the expected pathologic findings, and specific plans for their correction as well as a careful summary of the pertinent risks. Inasmuch as the initial talk with the surgeon is often frightening and intimidating to the patient, it is good practice to encourage the patient to call with any questions that arise after the in-office discussion. The preparatory discussion is often an ideal time to bring up the subject of visual documentation and indicate to the patient (and others who may accompany the patient) that there will be the opportunity postoperatively for reviewing videotapes or pictures obtained during the procedure. Visual documentation is routine in our practice and is encouraged for a variety of reasons. A complete discussion of the importance of documentation and the specific techniques involved in pelviscopic surgery may be found in Chapter 11.

Most pelviscopic procedures can be performed in the hospital outpatient surgical setting, with the patient planning on discharge the same day as surgery. Preoperative laboratory work varies from one institution to another but should include, as a minimum, hemoglobin or hematocrit determination, and urinalysis; for patients over the age of 35, an electrocardiogram and chest x-ray may be considered. Other studies specific for the patient's condition and important to the postoperative course may also be done at this time.

As mentioned earlier, pelviscopic surgery finds increasing application in patients of both sexes. However, the remaining discussion is confined to the gynecologic patient, with whom the author is most familiar.

Although the subject of anesthesia for endoscopic surgery is thoroughly discussed in Chapter 13 and is not included here, we should state that our preference is for general endotracheal anesthesia, except in exceptional circumstances.

Preparation of the Operating Room

Perhaps more so than with open abdominal surgery, it is vitally important that the operating room be thoroughly prepared for endoscopic procedures well in advance of the operation. In its simplest sense, this means that *all* of the appropriate equipment, instruments, and solutions must be prepared and ready for use *before* the patient goes to sleep. Pelviscopic surgery usually involves the division of tissue and always carries with it the possibility of unexpected bleeding. If bleeding occurs, it will be in a "closed" space accessible only to manipulation of the pelviscopic instruments; therefore it is critical that not only every instrument be sterile, unwrapped, and available *in the room* but that each instrument be in top working order as well. Every possible contingency must be anticipated. Equally important and deserving of special mention are the personnel involved on the surgical team. The operating team of nurses and technicians must be thoroughly experienced in pelviscopic surgery and completely familiar with all of the equipment and instruments used. This degree of preparation frequently calls for a marked change in attitude and approach by those in supervisory positions in the operating room. Although it may be desirable from the teaching standpoint to rotate inexperienced scrub and circulating personnel through cases of diagnostic laparoscopy, it is usually counterproductive with cases of complex laparoscopic surgery. The special instruments and equipment used for pelviscopic surgery or operative laparoscopy are not only frequently unique, they are often delicate and require that those handling them have experience in special techniques of cleaning, assembly, and sterilization. This degree of expertise is not merely desirable, it is *essential* to the efficacy of the procedure and the safety of the patient. Therefore it is strongly recommended that interested and skillful personnel be *permanently* assigned as part of the pelviscopic surgery team, and that they alone be responsible for the maintenance, readiness, and replacement of equipment. It should be the job of this dedicated team to ensure the completeness and workability of all instruments and equipment before the patient arrives in the operating room. This step reduces anesthesia time and goes far to ensure the smooth conduct of the procedure.

To help maintain the continuing dedication and spirit of the pelviscopic surgery team, it is good practice to involve them in as many aspects of patient care as possible. Holding frequent seminars and discussion groups and making sure that their suggestions and comments are given real consideration proves to be of lasting benefit to both surgeon and patient. The level of training and motivation of the team is critical to the best interests and efficiency of the pelviscopic surgeon, who should be actively and regularly involved in the in-service education programs and administrative matters affecting them. As new equipment, instruments, and techniques are introduced, they should be the subjects of regular discussion sessions. If this devotion to team involvement is consistent, the efforts are rewarded many times over by smooth, efficacious surgery accompanied by low morbidity and complication rates.

The surgeon also must play an important inspection role in the preoperative preparation of the operating room for endoscopic procedures. Minimally, it should include testing the equipment discussed in Chapter 2. Specific mention is made of checking the insufflator and reserve gas supply, making sure there are spare bulbs for the light source, overseeing the setup of the documentation equipment, and visually inspecting the sterile instrument table(s) to ensure that everything even remotely necessary is in the room. Once the surgeon is scrubbed and gowned, the inspection should include a final testing of the working condition of most common instruments.

Thus the preparation of the surgeon, the patient, and the operating suite are all essential areas of the overall technique and, although they do not guarantee it, are vital to the success of the pelviscopic procedure undertaken. Having considered the measures that must precede the actual surgery, it is appropriate now to move the discussion to the more technical aspects of advanced operative laparoscopy. In so doing we proceed from those aspects that apply to all cases to those that have narrower, less frequent application.

Pelviscopic Surgical Techniques

Procedures Common to All Pelviscopic Operations

Once the patient has been anesthetized and properly positioned on the operating table, the first step of any pelviscopic procedure is a brief bimanual examination. It is done primarily to determine the position of the uterus but also to identify any previously undetected adnexal enlargements as well. At the completion of the bimanual examination, the cervix is fixed with an instrument that allows manipulation of the uterus and chromotubation. We have found either the vacuum apparatus of Semm or the cannula designed by Cohen, fixed with a single-toothed tenaculum, to be equally effective for these purposes. Many excellent alternatives are available, but it should be remembered that if tubal patency is in question or will be reestablished during the procedure it is essential that whatever instrument is used it must be tightly approximated to the external cervical os to ensure that there is no back-leakage of dye during chromotubation.

FIGURE 3-1. Manual elevation of the abdomen for Verres needle insertion. (Reprinted from ref. 11, with permission.)

Pneumoperitoneum

The laparoscopic part of the procedure is then begun. Pneumoperitoneum is established as discussed in Chapter 2. Levine emphasized that during insufflation the abdominal wall should be elevated by the surgeon just above the level of the symphysis so as to present a right-angle target to the needle (Fig. 3-1). As for any laparoscopic procedure, it is important to remember that the needle must always be placed in the midline and directed toward the hollow of the sacrum during its insertion. The experienced surgeon is usually able to tell when the peritoneum has been punctured, but it is good practice to attach the barrel of a hypodermic syringe, containing a few milliliters of sterile saline, to the insufflation needle to ensure that there is good gravity flow of the saline into the peritoneal cavity. Insufflation (Fig. 3-2) can then begin using appropriate equipment. As presented in Chapter 2, it is here that we encounter the first real difference in technique between diagnostic laparoscopy and pelviscopic surgery.

FIGURE 3-2. Rounded distention of the abdomen after initial pneumoperitoneum.

Whereas any laparoscopic insufflator can be utilized for laparoscopy alone, proper instrumentation for pelviscopic surgery virtually dictates the use of an automatic, electronically controlled insufflator.

Initial Placement of Transabdominal Instruments

After withdrawing the insufflation needle, a semilunar or vertical incision is made (depending on the anatomic configuration of the umbilicus) of sufficient size to tightly accommodate the laparoscope cannula. The cannula with trocar is then inserted in a manner similar to the insufflation needle, making a Z tract for better hemostasis. The surgeon takes particular care to aim the instrument toward the midline of the hollow of the sacrum and away from any of the large vessels. Usually this direction is the same as that when aiming for the uterine fundus. We strongly recommend the use of a conical-tipped trocar, as distinguished from one with a pyramidal cutting tip. (Trocar and laparoscope insertion is also discussed in Chapters 1, 2, and 4.) The latter is much more likely to damage vessels in the abdominal wall and possibly cause a hematoma along the cannula tract. Should the fundus of the uterus be hit by the trocar, the small amount of bleeding that results may be easily controlled by coagulation. Once the cannula is in the abdomen, we have found it useful to simply release a small portion of gas to ensure that there is no fecal odor, which would indicate an intraluminal perforation of the bowel. Once confident of placement of the cannula tip, the gas tubing should be attached to the cannula and gas flow restored. The observation of a back-flow pressure below 15 mm Hg gives further assurance that the tip is in the free peritoneal cavity. The reader is referred to the section on entry (see Chap. 2) for further discussion.

The laparoscope itself (we prefer a 10-mm, 0° instrument) is then inserted and visually followed down the cannula by the surgeon to further ensure free placement of the cannula in the abdominal cavity. It must be emphasized here that for pelviscopic sugery, or for any form of advanced laparoscopic surgery, *there is no place for the single puncture, or "operating laparoscope."* The intricate manipulation of tissue required for this type of surgery requires that the surgeon have a maximum range of motion and that the view of the tissues being handled be as flexible as possible. Such a situation is almost never possible with the single puncture laparoscope where the instrument channel and optical axis are parallel and fixed.

Once the laparoscope has been inserted, the first observations should be for any possible damage from the perforating instruments and for distention of the urinary bladder. Should the bladder be full and obscuring a complete view of the pelvis, catheterization is accomplished with a small French catheter and a culture obtained if indicated.

The next step is establishment of secondary puncture sites. The number of such sites should be kept to a minimum but must be sufficient to accomplish the proposed operation. For simple cosmetic purposes, we prefer to place secondary puncture incisions *below* the level of the pubic hairline if possible. For this reason, usually while the pneumoperitoneum is being established, a No 10 scalpel blade may be used as a sterile "razor" to shave the pubic hair for a centimeter or two below this line. The first such site, usually placed in the midline, is utilized for a manipulating probe during the laparoscopic inspection of the pelvis and upper abdomen. During the inspection, the surgeon usually is able to determine the location and number of additional secondary sites necessary for the procedure contemplated. The actual placing of the secondary site cannula and trocar in every case should be directed by laparoscopic visualization so that inadvertent damage to intraperitoneal structures can be avoided. With few exceptions, the direction of placement of the secondary trocar must be *toward the midline* and away from the vital, fixed structures of the pelvic side walls. We have found it useful to attach the video camera before making the secondary punctures so that their placement can be visualized by the entire team, keeping in mind the principle that the more eyes available for observation the better and safer is the procedure. This team approach has prevented more than one potential problem over the years.

In certain cases, such as with the laparoscopic laser where the angle of the beam to the target tissue is critical or where upper abdominal procedures are contemplated, it may be appropriate to place the initial secondary sites above the pubic hairline. It should be remembered that cosmetic considerations, although important, are in the end secondary to the demands of accurate, safe surgery. There are times when additional secondary sites must be chosen in the upper abdomen or out toward the flank. So long as such placement does not compromise abdominal organs or threaten uncontrollable bleeding, the principle of convenience for surgical technique should be followed. Before puncturing the abdominal wall with any instrument it is appropriate to backlight the intended site with the laparoscope to avoid damage to large blood vessels in the subcutaneous layers and to then follow the intraperitoneal path by direct laparoscopic visualization.

The use of multiple secondary puncture sites is the usual case with operative laparoscopic procedures, which means that a number of cannulas of various sizes must be in readiness on the instrument table.

Laparoscopic Inspection

The secret of successful and complete laparoscopic evaluation of the pelvis and upper abdomen is organization. There is no better time to involve the entire pelviscopic surgery team than during the initial inspection, and their attention should be directed to the video monitor. The video technique is basic to every laparoscopic procedure and should be used throughout the entire case. It is also useful to comment aloud as the orderly investigation of the abdomen proceeds. Not only does this method further involve the other personnel in the case, it frequently serves as the basis for their reminding the surgeon of some condition described earlier but later forgotten. Comments are easily recorded as part of the videotape using a small lapel-type microphone clipped to the upper part of the surgeon's gown and connected to the VCR preamplifier.

An orderly anatomically organized approach, allowing close visual inspection of every organ and space possible, should be developed by the pelviscopist and used consistently in each case. Although the area of the contemplated surgery may be the focus of attention, the surgeon must be careful not to become so preoccupied with it as to neglect equally careful inspection of all other areas *before* beginning the operative procedure itself.

The organs of the pelvis lend themselves well to symmetric, systematic evaluation. The usual approach is from one side around to the other starting with the infundibulopelvic ligament at the pelvic brim. A general observation of the condition of the bladder, uterus, and rectosigmoid should be followed by a systematic inspection of the ovary, fallopian tube, and broad ligament on each side. Care should be taken to rotate and lift the ovary, observing its entire cortical surface if possible, by placing an atraumatic forceps on the ovarian ligament for manipulation. It should not be forgotten, for instance, that endometriosis of the ovary often involves the lateral cortex, which is in apposition to the medial leaf of the broad ligament. This area is seen only with some manipulation and so can be easily overlooked. As the inspection proceeds, it is perfectly appropriate, and often necessary, to divide (and if possible remove) adhesions that hinder visualization. Judgment must be exercised in this regard, however. Adhesions that obscure areas not likely to be involved in the problem under investigation or in its treatment are probably best left undisturbed. The entirety of the fallopian tube should be observed. Attention to its caliber, course, and color often suggests the presence of endosalpingeal disease or reveals tuboovarian adhesions possibly responsible for impaired ovum pickup. The condition of the tubal fimbriae, especially in cases of infertility, should always be observed and carefully documented either visually or verbally. The round ligaments should be traced to their disappearance into the internal inguinal rings, and, if possible, the caliber of the ring noted for the possibility of hernia formation. Detailed inspection of the viscera should be followed by an area inspection of the parietal peritoneum for active endometriosis, Allen-Masters scarring, or other abnormalities.

It should never be forgotten that laparoscopy affords a rare opportunity for direct observation of areas of the body otherwise hidden from view. The unique nature of this opportunity must be appreciated by the surgeon so that the observations not be casual or "routine." Each patient is different. Careful observations become a vital part of the record of the patient, sometimes proving to be critical to medical care at some future date. This opportunity must be seen for what it is and the observations recorded as carefully and accurately as possible. Because the opportunity is unique, accurate visualization and evaluation of the upper abdomen is no less important than that of the pelvis. Neglecting to take the time for this essential observation, which not infrequently unmasks unsuspected pathology, is to be condemned.

For visualization of the upper abdomen, it is convenient to start in the right lower quadrant, with the vermiform appendix if present, and proceed up the right peritoneal gutter to the right lobe of the liver, dome of the gallbladder, and right hemidiaphragm. The inspection is then carried across the midline, past the falciform ligament and the left lobe of the liver, to the greater curvature of the stomach and down the left side to the sigmoid and pelvic brim, making note of the serosal surface of those portions of the large and small bowel encountered. If inspection reveals the presence of an unsuspected lesion of the liver, the surgeon should not hesitate to consider pelviscopic biopsy by a punch technique or percutaneous needle. An exception to this approach is worth mentioning. If the hepatic lesion resembles a hemangioma, it is probably better to leave its diagnosis to other, less invasive means because of the probability of initiating significant, and possibly uncontrollable, bleeding.

Only when a complete visual inspection has been made (and, if possible, documented on film or videotape) should the surgeon proceed to the planned operative pelviscopic procedure or to additional surgery dictated by the inspection findings.

Biopsy of an endometrioma is usually done as an integral part of its extirpation and is described below (see Ovarian Biopsy). It is, however, occasionally important to have the capability of removing a sample from the wall of the structure to confirm a benign state. Following aspiration of the contents of the endometrioma, biopsy can be accomplished by firmly grasping the partially collapsed wall in locking atraumatic forceps through one secondary site while using the serrated scissors through another to excise the portion of wall held on stretch. The forceps, with the specimen intact, are then eased back through the secondary cannula and the tissue submitted for frozen or permanent section.

Should it be important to biopsy an endometriotic implant on the serosal surface of the tube, only a shallow bite of tissue should be obtained, and no coagulation of the site should be attempted. It is usually inadvisable to obtain such a biopsy in a woman whose fertility potential should be preserved. A technique similar to that used with the tube is employed for implants occurring on the serosa of the bowel, but extreme caution must be exercised. With the possible exception of low power laser, *destructive thermal energy must not be used* on the *bowel at pelviscopic surgery* because of the likelihood of necrosis and delayed perforation. It is definitely the better part of valor to leave the treatment of surface bowel endometriosis to postoperative suppressive medical therapy. (The reader is referred to Chap. 17 for further discussion of endometriosis.)

Specific Pelviscopic Procedures

Many maneuvers and procedures are common to almost every pelviscopic operation. It is to those that our discussion now turns. (The reader is referred to Chapters 5, 6, 8–10, 16, and 17 for further information on technique.)

Adhesiolysis and Resection

Adhesions of the pelvis, and frequently of the upper abdomen as well, are the result of an inflammatory process, which in turn is the physiologic "healing" reaction of the peritoneum to endometriosis, infection, or previous surgery. Although seldom the source of abdominal pain, adhesions are frequently involved causally in infertility and as such are the proper subject of pelviscopic surgery. When interfering with the process of laparoscopic inspection, as discussed above, or if the apparent cause of a specific problem, adhesions should be lysed and if possible removed. The technique conforms to good surgical principles and starts with careful observation, conducted at high magnification, for determining the degree of vascularization of the adhesion and identifing tissue planes between the adhesion and the organs to which it is attached. Blunt, indiscriminate teasing of vascularized adhesions usually results in needless bleeding and should be avoided. The most effective technique is to place the adhesion under countertraction with atraumatic forceps, identify the course of the contained blood vessels, and apply heat coagulation to the vascularized area with crocodile forceps (Fig. 3-3). Bipolar, or even unipolar, electrocoagulation may also be used if appropriate care is exercised to avoid injury to other tissues. In some cases surface coagulation with a button electrode or point endocoagulator is adequate to ensure hemostasis at the time of division of the adhesion. When adhesions involving the fallopian tube are divided, extreme care must be taken to avoid injury to the tube itself. It is best accomplished by utilizing laser, the heat endocoagulator, or very low electrocoagulating current. The sharp high-frequency unipolar knife or needle used at a low current setting, is a useful instrument for this purpose, allowing the surgeon to incise a very thin coagulated line of tissue close to the tube without subjecting it to damage.

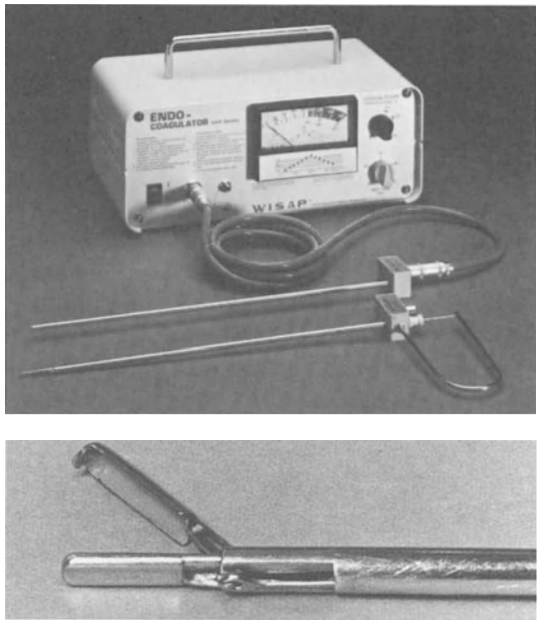

FIGURE 3-3. Thermal coagulation unit with Semm crocodile forceps (bottom) and point coagulator. (Courtesy of WISAP, Sauerlach, West Germany.)

Postinfectious adhesions are more often thin and relatively avascular responding to careful blunt dissection, whereas postoperative adhesions are usually denser, better vascularized, and require hemostatic control and sharp division. In the former case, traction between instruments or countertraction with a single blunt instrument commonly results in separation of the adhesion in a tissue plane, allowing the surgeon to either remove it or divide it cleanly. When freed, the adhesion should be cut and removed through one of the secondary puncture cannulas. In the case of denser postoperative formations, it is sometimes possible only to coagulate and divide the adhesion, leaving it attached to the organs involved. In the interest of minimizing the re-formation of adhesions, it is always desirable to both divide and *remove* the adhesion if it can be done without damaging the attached organs. Bowel adhesions involving the uterus or adnexae present a challenge and require considerable experience. When their origin has been postoperative, it is usually possible, with patience, to completely restore the normal anatomic relations. It is mandatory in such cases to be able to visualize the line of attachment of the adhesion to the peritoneal serosa. It is best accomplished by placing the adhesion under considerable stretch and observing the "white line" of the peritoneal reflection. In this instance, the adhesion is best divided with CO_2 laser, sharp hook scissors, or a sharp knife, cutting carefully along the line of reflection. On the other hand, when the adhesion is the result of long-standing endometriosis and involves the rectosigmoid and posterior uterus, it is usually wiser to make no attempt at separating the attached organs. Not infrequently in such cases where the rectum or rectosigmoid has become densely adherent to the back of the uterus, the medial leaves of the broad ligaments are drawn toward the midline, often carrying with them the ureters, which can easily be damaged in the attempt at adhesiolysis. In the case of bowel adhesions, the work should proceed in small steps and only under direct vision, allowing positive identification of each area of tissue, its attachments, and its contained blood vessels. Hemostasis should be maintained as the work progresses and not left to correction after the fact of significant bleeding. Bipolar coagulation with paddle-shaped forceps is convenient for this purpose, although the button electrode is also useful. When possible, any vessels in the proposed incision line should be coagulated *before* they are divided. Inevitably some vessels escape detection and bleeding ensues. Control with bipolar forceps and minimal coagulating current is preferred if the bleeding site is accessible. If not, the button probe, with use of either thermal or unipolar energy, should be used. The loop ligature is also an excellent means for accomplishing hemostasis.

Adhesiolysis probably finds its most frequent application in cases of female infertility, where reestablishment of the normal anatomic relations between the uterus, tubes, and ovaries is important. However, the occasional patient complaining of chronic pain sometimes benefits from removal of an adhesion that distorts the bowel, ovary, or tube in such a manner as to cause intermittent or chronic pain.

Pelviscopic Biopsy

It is occasionally the purpose of pelviscopic surgery to obtain tissue for histologic examination. Biopsy at laparoscopy may differ from that at pelviscopic surgery in extent and instrumentation available. For example, biopsy of an endometriotic implant is an important step for establishing that diagnosis and is essentially no different in either procedure. The simplest, least traumatic method involves use of toothed biopsy forceps, which are found in most laparoscopy sets. Although usually adequate for small implants, these forceps are not capable of securing much tissue. The range of instrumentation available to the pelviscopist, however, allows sampling of tissue in much the same way as at open surgery. The biopsy forceps are supplemented with sharp unipolar knives, scissors of many types, and an entire range of grasping instruments, enabling the surgeon to obtain generous samples of the tissue to be examined and to control hemostasis in the process (see Chap. 2).

Biopsy of Endometriosis

Implants of endometriosis are most commonly found in the cul-de-sac and on the uterosacral ligaments in areas easily and safely available for biopsy (see Chap. 17). Occasionally, peritoneal implants overlay vital structures such as the ureter or iliac vessels, or they may involve the bladder or bowel serosa. Because the biopsy is primarily for confirmatory purposes, a representative lesion in a biopsy-safe area should be chosen. When it is not possible, a generous biopsy specimen can often be obtained (even from the pelvic side wall) by grasping the surface of the parietal peritoneum adjacent to the implant with atraumatic grasping forceps, elevating it away from the vital structure, and excising the tissue with the sharp unipolar knife or the hook scissors. It is probably unnecessary to close the resultant defect in the peritoneum, as second-look laparoscopy consistently shows complete nonadherent healing. Some authors have advocated suturing the defect using the endosuture technique to be described later in this chapter.[1] There appears to be little or no advantage to doing so. It is important, however, especially when a small specimen has been obtained with biopsy forceps, to coagulate the site in order to destroy any residual endometriosis and secure hemostasis.

Although it is preferable to obtain biopsies without the use of electrocoagulation, which can distort the histology, it is possible to utilize a high-frequency unipolar current for cutting while protecting the tissue at the same time. The toothed biopsy forceps, insulated for unipolar coagulation, are used. The lesion is grasped and the forceps closed completely over the tissue. A cutting current then applied to the forceps results in division of the tissue with coagulation of the biopsy site while protecting the tissue within the jaws of the instrument from damage. (The current flows over the surface of the instrument into the site and does not course through the tissue itself.) Deeper biopsies can be obtained by placing the forceps back into the same site and removing additional tissue in a similar manner.

Ovarian Biopsy

There are two general reasons for obtaining biopsy tissue: (1) evaluation of ovulatory and endocrinologic activity; and (2) determination of the histologic character of solid or cystic ovarian lesions.

The histologic examination of ovarian cortical tissue is often of importance when evaluating the infertile woman. Although a wedge of the ovary can be obtained with a pelviscopic technique, sufficient tissue can usually be obtained for hormonal and oocyte evaluation by "two-step" punch biopsy. The cylindrical toothed biopsy forceps are used for this type of biopsy (Fig. 3-4). We prefer to use the insulated unipolar variety for better control of bleeding. The ovary is steadied with atraumatic grasping forceps and the cortical biopsy site grasped widely with the unipolar forceps. The jaws of the forceps should encompass as much tissue as allows their closure. The instrument is then twisted through one or more complete turns with or without the application of cutting current. This specimen is removed and the forceps emptied outside the abdomen. With the ovary held in the same position by an assistant, the biopsy forceps are reinserted into the same site on the ovary. The jaws are then opened as wide as the tissue allows and the instrument pressed more deeply into the substance of the ovary. After closing the instrument a coagulating current is applied, and the same twisting motion is used to free the specimen. We recommend the use of electrocautery with this second "bite" because of the deeper penetration into more vascular areas near the hilum of the ovary. The biopsy site should be left open and dry.

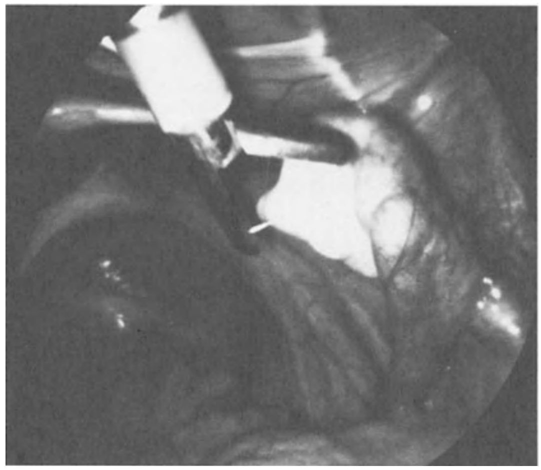

FIGURE 3-4. Biopsy of the ovary using toothed biopsy forceps.

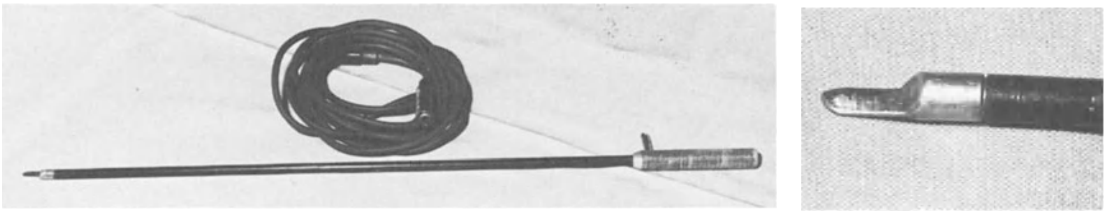

FIGURE 3-5. Left: Sharp unipolar knife. Right: Magnified view of the tip.

This two-step process generally ensures that sufficient cortex for adequate diagnostic examination is obtained and obviates the need for more extensive incision.

For accurate determination of the histologic character of various ovarian lesions, larger biopsies must often be obtained. It is important that pelviscopic sampling of ovarian tissue be reserved for those lesions that are clearly clinically benign, which does not mean that on occasion biopsy of a malignant lesion does not occur. Not only does this type of biopsy require considerable technical skill on the part of the surgeon, it also demands clinical in-situ experience with ovarian lesions and sound judgment with respect to the prudence of obtaining tissue at a "closed" (versus an "open") procedure. Diagnostic laparoscopy and pelviscopic surgery done because of the presence of an adnexal mass must be preceded by a careful history, bimanual examination, and ultrasonic or radiologic studies. Any strong preoperative suggestion that an adnexal mass may be malignant contraindicates the pelviscopic approach, except for the rare instance of probable advanced disease when tissue for diagnosis is critical to planning therapy.

As one might expect, the pelviscopic techniques for solid and cystic masses of the ovary differ. In the former the object is usually to obtain a wedge of tissue, whereas the latter case dictates aspiration of fluid, wide opening of the cystic structure, sampling of the wall, and removal in its entirety if possible. In both instances, closure of the defect is usually a matter of preference or, in some cases, hemostasis.

For solid masses wedge resection, for either diagnosis or treatment in cases of polycystic ovarian syndrome, is a procedure particularly suitable to the pelviscopic approach. The ovary is first fixed by atraumatic grasping forceps placed on the ovarian ligament and at the distal pole. Next, a button electrode or point endocoagulator is used to coagulate the ovarian cortex over two incision lines that converge at the ovarian poles. A wedge of tissue is removed with a sharp unipolar knife (Fig. 3-5) with cutting current. Starting at one pole of the ovary, the knife is inserted to its full depth (approximately 0.9 cm) into the substance of the ovary and carried with cutting current to the opposite pole using a slight up-and-down "sawing" motion. The other side of the wedge is most easily cut by starting again from the original pole, bringing the incision to meet the first. Unless the wedge is carried too deeply into the vessels of the ovarian hilum, usually remarkably little bleeding is encountered. With the ovary laying open and fixed with the grasping forceps, complete hemostasis can be accomplished with the unipolar knife or a button electrode while the excised specimen is removed and placed in the cul-de-sac. In our early experience, we elected to close the ovary with interrupted endosutures of chromic catgut. In more recent cases, we have found that complete healing, almost always *without adhesion formation,* ensues even when no sutures are placed.

Before attempting to place intraabdominal sutures using pelviscopic instruments, considerable practice and experience is necessary. A pelviscopic trainer is an outstanding device for acquiring the requisite

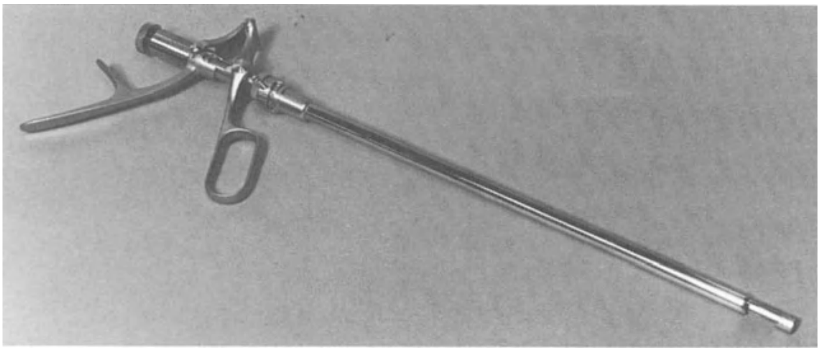

FIGURE 3-6. Semm tissue extractor. (Courtesy of WISAP, Sauerlach, West Germany.)

skill[5] (see Fig. 1-14), and there are several training models available. We strongly suggest that a training model be part of the instrumentation for every endoscopy program. Although the catgut sutures with straight cutting needles commercially prepared for pelviscopic surgery are useful, we have found that many of the sutures designed for otolaryngologic surgery are smaller and work well. The instrumentation and techniques are discussed in Chapter 2 (see Fig. 2-28).

Removal of tissue from the abdominal cavity depends on its size. If it is relatively small and its structure is not critical to the diagnosis, the morcellator (which is made as either a manually or electrically driven instrument) is ideal (Fig. 3-6). If the morcellator is not available, the time-worn maneuver of pushing the specimen back through the laparoscope cannula can be used. In this maneuver, the tissue is grasped with a second puncture instrument and brought under direct vision to the distal end of the laparoscope cannula with both cannulas lined up directly opposite each other. The tissue is introduced into, and slowly pushed through, the laparoscope cannula while the laparoscope itself is withdrawn. Once past the valve, the tissue can be grasped directly with toothed forceps and removed from the cannula.

The third alternative, tissue removal through a colpotomy incision, is perhaps the best for large specimens and for those that must remain intact. As newer instruments allow more extensive procedures and removal of large tissue specimens, this method is finding increasing application in pelviscopic surgery. With the cul-de-sac under direct vision, a long Kelly clamp is inserted into the vagina and pushed firmly against the posterior fornix until its position can be seen from above with the laparoscope. The jaws of the clamp are then opened about 1 cm so that the unipolar knife can be used to make an incision between them into the vagina. Occasionally, it is possible merely to push the clamp through the fornix under direct vision from above. The opening can be enlarged to any appropriate size before starting the specimen through with grasping forceps. When the specimen has been pushed far enough to be visible from below, it is grasped and extracted with gentle traction. Closure of the colpotomy, which should be done as soon as the specimen is out, is accomplished transvaginally with interrupted absorbable sutures placed in the usual manner. At the actual time of removal of the specimen, there is likely to be a significant loss of gas from the abdominal cavity. However, the pneumoperitoneum is re-established rapidly with the electronic insufflator and the procedure continued.

The subject of ovarian masses and the strategies to follow to obviate surgery for malignancy are covered in Chapter 6.

If a cyst appears to be abnormal but benign, it should be the object of the endoscopic surgeon to make the diagnosis and remove the cyst. Specifically excluded by the word "abnormal" are the usual functional cystic structures of the normal ovary, which are all too often surgically removed. The experienced surgeon should be able to identify a corpus luteum or a Graffian follicle. Biopsy of the former can involve significant bleeding and serves no purpose. The latter may not bleed, but its biopsy is of no salutary value. A follicular cyst, however, may be large; and although it usually decreases in size naturally with falling follicle-stimulating hormone (FSH) levels, it is appropriate to aspirate its contents if it is large enough to be symptomatic. The first fluid obtained must be inspected immediately and carefully for color, clarity, and consistency. If the fluid is mucinous, pelviscopic surgery should be terminated and the ovary removed to make the distinction between mucinous cystadenoma and cystadenocarcinoma. Removal in this case should be by laparotomy during the same anesthesia, with frozen section diagnosis determining the necessity for further surgery in the case of malignancy. Although most surgeons (including the author as of the date of this writing) believe that pelviscopic removal is contraindicated in the case of a mucinous cyst, it is interesting to speculate if this assumption is correct. If the mucinous ovarian cyst is decompressed by aspiration, resected pelviscopically, and removed through a colpotomy incision, and if frozen section shows it to be benign, would spillage of some of the cyst contents have an adverse effect on the patient? The author knows of two such cases in which the histology revealed mucinous cystadenoma (benign). In both instances thorough lavage of the pelvis was carried out with 2–3 liters of normal saline after removal of the cyst. Recent inquiry reveals that these patients, now 4 and 6 years after pelviscopic surgery, have had no apparent adverse effects and currently have no evidence of tumor.

In summary, ovarian biopsy is an appropriate procedure for pelviscopic surgery when there is no evidence of malignancy. Common sense, experience, and an unswerving regard for the ultimate safety of the patient are the basic factors that guide the surgeon. (See Chapter 6 regarding ovarian pelviscopic surgery.)

Other Biopsy

Whenever histologic examination of intraabdominal tissue is important to establishment of a diagnosis, pelviscopic biopsy should be considered. This practice applies not only to cases of suspected or known malignancy but to those involving pain, a mass, endocrine dysfunction, or infertility as well. Any area suspicious, by reason of appearance or history, that can be safely sampled or removed should be biopsied. Appropriate instrumentation for a wide variety of biopsy techniques must therefore be available for every case.

Hemostasis

In the early days of modern laparoscopy, perhaps the most common reason for immediate laparotomy was uncontrolled intraabdominal bleeding. With increased experience and the development of better instrumentation, the ability to achieve and maintain hemostasis at endoscopic surgery has reduced the incidence of major vessel complications to less than 0.7%.[6] Whether performing a diagnostic procedure with simple lysis of adhesions or complex operative pelviscopic surgery, the two requisites for successful control of bleeding are clear visualization of the bleeding site and patience. (Specific instruments used to achieve hemostasis are presented in Chapter 2. Further details on technique are conveyed in this chapter.)

Although hemostasis should be a principle of every surgical procedure, it must be remembered that bleeding is a natural consequence of cutting tissue. Even when every effort is made to maintain hemostasis by coagulation at the operative site, all too often some bleeding occurs after the tissue is divided. Venous oozing is usually a minor problem and is easily controlled by application of heat or high-frequency coagulating current to the site, using the mimimum energy necessary to achieve a dry area. It is helpful to identify the discrete source of the bleeding and to apply the current or heat only to that spot. As previously discussed under adhesiolysis and resection, the loop ligature provides good hemostasis. When the anatomic situation allows, it is preferable to grasp the bleeding tissue with bipolar forceps and apply coagulating current. In this situation, the current should be applied for sufficient time to make the tissue nonconductive. Most bipolar generations have a current meter to assist in making that determination.

When dividing any but the filmiest of adhesions, good technique requires visual determination of the vascularity of the adhesion before proceeding. In most cases, the vessels traverse the adhesion and are best controlled with crocodile heat coagulation forceps or bipolar forceps applied across the adhesion in the projected line of division. If the adhesions are thin and relatively avascular, unipolar scissors used with low coagulating current are all that is usually necessary.

Arterial bleeding is often dramatic but not necessarily more serious. It can usually be controlled safely without resorting to laparotomy. If a small artery is severed while tissue is being dissected, bipolar forceps should be inserted immediately and the bleeding site grasped firmly. Accuracy of the instrument application is critical and evidenced by cessation of the bleeding. Coagulating current should be applied for an appropriate time and then the tissue held firmly in the forceps for 2–3 additional minutes. It is important to remove the coagulation forceps slowly and with as little trauma as possible to keep from dislodging the clot. The site should be observed under high magnification for completeness of hemostasis and should be carefully observed again before the end of the procedure.

When it is not possible to grasp a bleeding site with forceps, the bleeding may be stopped by applying pressure to the area. Because it is not feasible to use a sponge and forceps for this purpose, a nearby structure may be used that can be brought over with atraumatic forceps to both cover and apply pressure to the bleeding site. The uterus is perhaps the best organ for this purpose, and often bleeding in the cul-de-sac can be controlled by simply retroverting the uterus and holding steady pressure with the cervical manipulator. Occasionally, when a discrete bleeder is directly accessible to two secondary puncture sites, successful hemostasis can be achieved by placing the area between two instruments and holding steady pressure for a period of 4–5 minutes. Again, clear observation and patience are paramount.

In rare cases of significant posterior pelvic bleeding not responsive to the above methods of control, it is possible to introduce a sponge and sponge forceps into the pelvis under direct laparoscopic control through a colpotomy incision made in the fashion described above. In one case of arterial bleeding from a small artery in the pelvic side wall following oophorectomy, the author was able to use this method successfully, holding pressure with the sponge for a full 10 minutes, and then observing the area carefully with the laparoscope.

In most circumstances bleeding at pelviscopic surgery is minimal or controlled and should not be considered a complication. However, bleeding of significant volume or rate, either intra- or postoperatively, is certainly a complication and must be treated promptly and aggressively. Intraoperative hemorrhage is almost always apparent and treated quickly by whatever means is appropriate. On the other hand, postoperative bleeding, which most often remains undetected until failing vital signs herald its presence, is a complication of the first 12–24 postoperative hours. For this reason, when the pelviscopic procedure involves considerable tissue dissection or when a vascular pedicle remains (e.g. following oophorectomy), the patient should remain quiet and in the

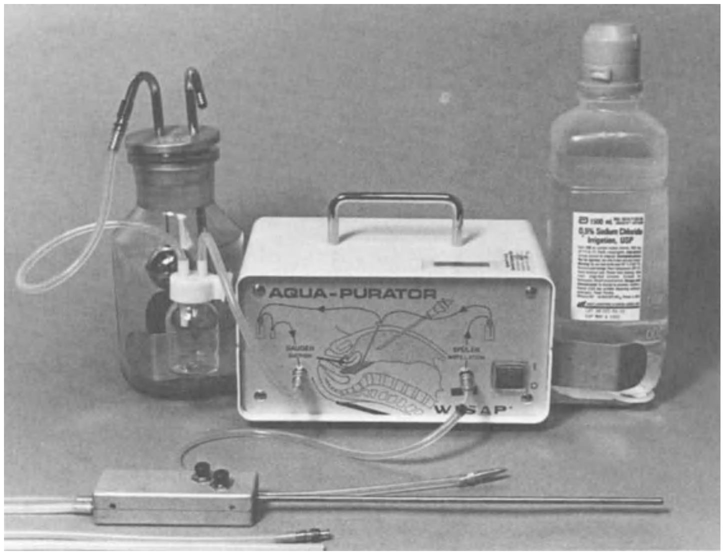

FIGURE 3-7. Semm Aquapurator. (Courtesy of WISAP, Sauerlach, West Germany.)

hospital overnight to ensure that no intraabdominal bleeding occurs.

Peritoneal Lavage

After blunt or sharp dissection or after biopsy, lavage with the Aquapurator (described in Chapter 2) is an ideal method for localizing bleeding points and keeping the area clear to observe hemostasis (Fig. 3-7). In each case where extensive resection or repair of tissue has occurred, thorough lavage with as much as 4 L of normal saline is appropriate so that the pelvis can be left as clean as possible. It should be particularly noted that because the vacuum for the aspirator is powerful it is essential that an automatic, rapid-flow insufflator be used to continuously replace the lost pneumoperitoneum.

Prevention of Postoperative Adhesions

The subject of postoperative adhesion formation and prevention is complex in the extreme and far from being completely understood. Although it is considerably beyond the scope of this chapter to discuss the subject in any detail, the use of high-molecular-weight 32% dextran-70 (Hyskon, Pharmacia Laboratories, Piscataway, NJ) is worth comment.

There is reason to believe, from laboratory and animal data, that instillation of 100–150 ml of Hyskon into the peritoneal cavity just prior to withdrawing all of the pelviscopic instruments results in a decrease in the incidence of postoperative adhesion formation.[7–10] This reaction appears to be based on the hydrophilic property of the hypertonic solution and its capability to draw and maintain a critical amount of fluid into the peritoneal cavity for sufficient time to interfere with the organization of collagen from fibrin deposition. Although not numerically documented, in the author's experience the use of this method exclusively since 1984 has resulted in far fewer postoperative adhesions observed at second-look laparoscopy. Of course it should be remembered that post-pelviscopic surgical adhesions are encountered considerably less frequently than those following laparotomy. When open surgery is necessary, it is good practice to instill Hyskon just as one would during pelviscopic surgery.

The long-advocated use of steroids or antihistamines, although seemingly founded on valid principles, lacks conclusive evidence of efficacy with respect to postoperative adhesions and is not recommended.

Conclusion

It should be apparent that knowledge of the basic elements of successful endoscopic surgery and of the techniques common to most such procedures is requisite to the performance of the more complex specific operations to be described in the following chapters. The reader is encouraged to remember that with pelviscopic surgery each nuance of dexterity, each detail of technique, and each extension of skill is based solidly on the essential principles that are the foundation of all surgery.

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4
Open Laparoscopy

HARRITH M. HASSON

Laparoscopy can be performed with the use of a small abdominal incision (open method) or with insufflation needles and sharp trocars (closed method). The difference between the two techniques is the method of abdominal entry, the type of equipment used, the timing of insufflation, and the type of abdominal wall closure. All other aspects of laparoscopy remain unchanged.

With open laparoscopy, the abdomen is first entered through a small umbilical incision under direct vision. A cannula carrying a blunt obturator is then introduced into the peritoneal cavity, and gas is insufflated directly through the cannula. The obturator is replaced by the laparoscope. At the end of the operation, the abdominal wall is closed in layers.

With closed laparoscopy, a needle is inserted through the abdominal wall and used to insufflate gas into the peritoneal cavity. After the abdomen is distended a small skin incision is made, and a cannula bearing a sharp trocar is thrust forcibly into the abdomen. The trocar is removed and replaced by the laparoscope. At the end of the operation, the skin wound is approximated, but the gap in the fascia is not repaired, as it is not accessible.

Surgical Anatomy

The abdominal wall in the lower border of the umbilicus is composed of the peritoneum as well as deep fascia fused with skin. There are no subcutaneous adipose tissues between the skin and fascia in this area, regardless of degree of obesity. This unique anatomic relation is the result of events that occur at the time of birth. Essentially, the postnatal umbilical scar is drawn firmly against the adjacent umbilical ring and linea alba by fibrous cords representing the non-functioning umbilical vessels and urachus. During adult life the puckered adherent skin of the umbilicus appears retracted underneath the level of the skin of the rest of the abdominal wall. A retracted area within the lower border of the umbilicus represents the position where the skin is fused with the linea alba.[1] Incising the skin overlying the lower margin of the umbilicus immediately exposes the deep fascia (linea alba). Superiorly, the fascia is fused with the skin; caudally, the fascia is attached to the skin with a few membranous and loose connective tissue fibers. This natural cleavage plane defines a convenient window for performing open laparoscopy.[2] (Fig. 4-1).

In 1862 Langer[3] described natural skin cleavage lines resulting from the topographic alignment of collagen bundles and the lines of associated tension. Incisions made along or parallel to these lines heal better with less keloid formation than incisions that cut across the lines.[4] Incisions that cross the lines of Langer tend to gape as the forces of tension resulting from the cut collagen bundles pull the wound edges apart.

In the area of the umbilicus, Langer's

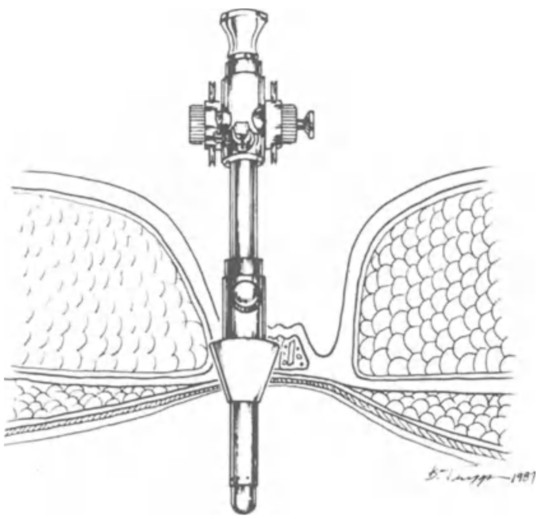

FIGURE 4-1. Open laparoscopy cannula inserted into the abdomen through the natural umbilical cleavage plane.

TABLE 4-1. Basic instruments for open laparoscopy.

Instrument	No. required
Allis clamps	2
Knife handle	1
Small blade	1
Straight scissors	1
Tissue forceps with teeth	1
Right-angle skin hook	1
S-Shaped retractors	4
Short needle holder	1
Kocher clamps	2
Small curved hemostats	4

lines run vertically, making a sunburst appearance. A study dealing with laparoscopy incisions at the lower umbilical edge has shown that vertical incisions resulted in better apposition of skin edges and a superior cosmetic scar than do transverse incisions.[5] My experience confirms this observation. Additionally, the operation of open laparoscopy is made easier with the use of a vertical incision that begins within the umbilicus at the surgical landmark of retracted skin and proceeds caudally to the rim of the umbilicus and beyond. The umbilical window, as previously defined, is found consistently near the upper edge of the incision. Transverse skin incisions placed at more superior or inferior levels require subsequent dissection in the opposite direction to expose the window or cleavage plane (Fig. 4-2).

Instrumentation

Basic instruments needed for open laparoscopy are listed in Table 4-1 and shown in Figure 4-3. The S-shaped retractors are used to expose the small operative field. Each possesses two retracting ends: one curved to retract superficial layers of the abdominal wall without slippage and the other flat to retract deeper layers while using minimal space. Standard laparoscopic equipment is used with the exception of the primary cannula. The open laparoscopy cannula is fitted with a cone-shaped sleeve that slides freely over the cannula's shaft but can be secured to the shaft with a metal screw. A blunt obturator replaces the conventional sharp tro-

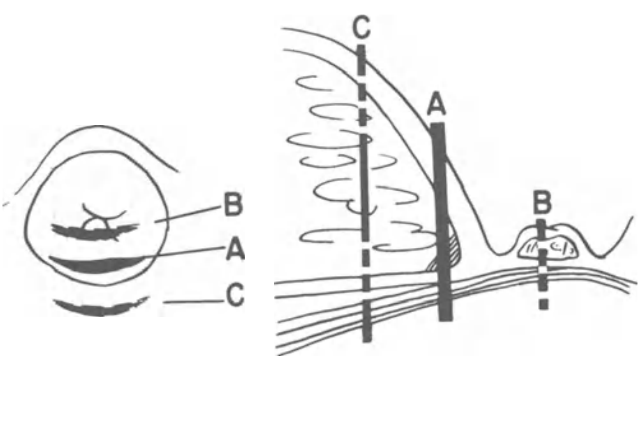

FIGURE 4-2. Transverse skin incisions placed at various levels relative to that of the umbilical window.

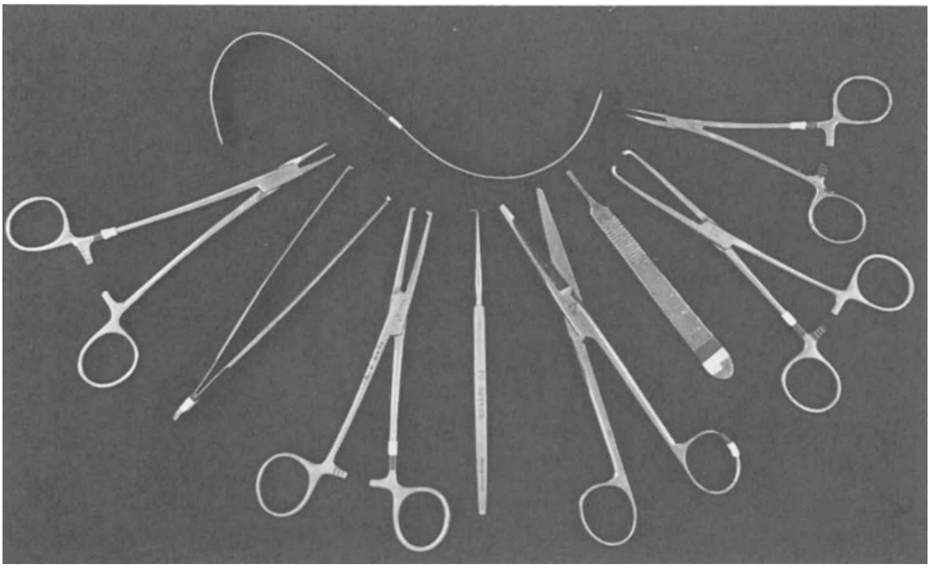

FIGURE 4-3. Basic instruments for open laparoscopy.

car (Fig. 4-4). Gas insufflation needles and sharp trocars are not used for open laparoscopy.

Technique

Skin Incision

Following satisfactory anesthesia, the skin of the lower umbilical fold is held under tension by two Allis clamps (Fig. 4-5). The skin is incised vertically at the 6 o'clock position for a distance of 1–3 cm depending on the degree of patient obesity. The incision is begun inside the umbilicus and extended inferiorly, as discussed. (Fig. 4-6). The size of the incision can be limited to 1 cm in many patients. However, a larger incision is recommended in the initial stages of a surgeon's experience.

Although previous umbilical surgery, including laparoscopy, alters the normal anatomic relations and increases technical difficulty, it is rarely necessary to change this preferred abdominal entry site. However, occasionally incisions can be made in the midline 3 cm below the umbilicus and in the right lower quadrant for the procedure of open laparoscopy.

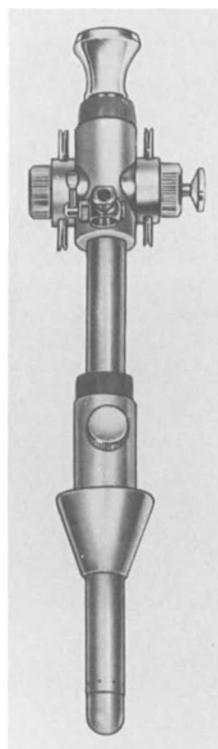

FIGURE 4-4. Open laparoscopy cannula.

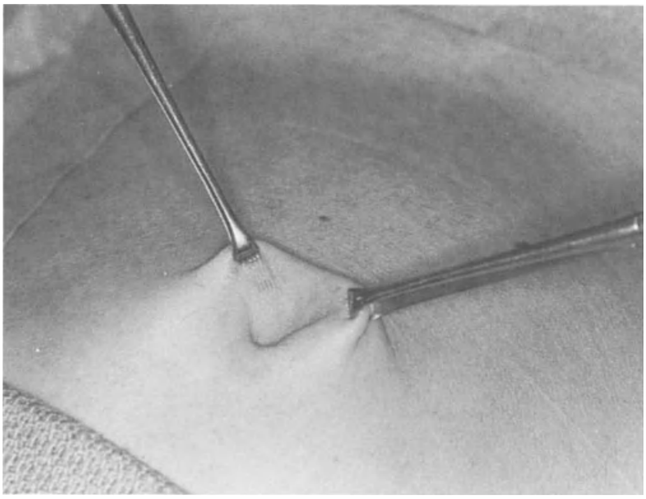

FIGURE 4-5. Stretching the skin prior to incision.

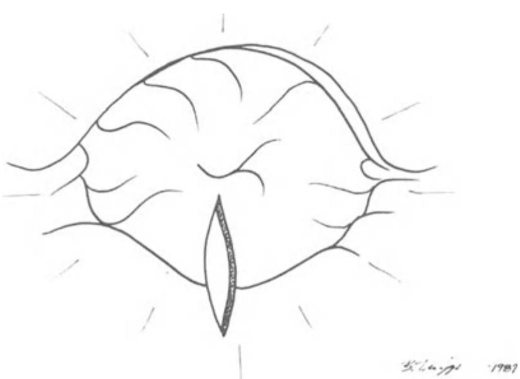

FIGURE 4-6. Vertical skin incision.

Exposure of Deep Fascia

The Allis clamps are repositioned on the skin edges and used for retraction (Fig.4-7). The curved ends of the S-shaped retractors are placed within the wound, and the edges are retracted laterally along a horizontal plane, not upward. To maintain exposure of the midline and prevent shifting of the operative field toward the rectus muscle, the amount of retraction applied to the sides of the incision must be equalized. Closed scissors are introduced in the upper angle of the incision to palpate the fascia and to identify

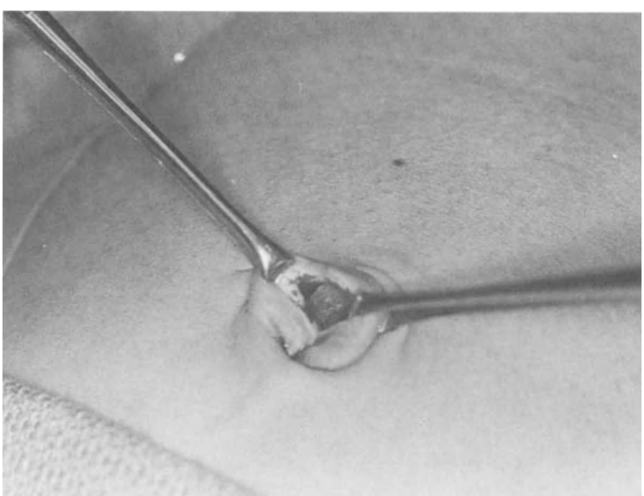

FIGURE 4-7. Retraction of the skin edges after incision.

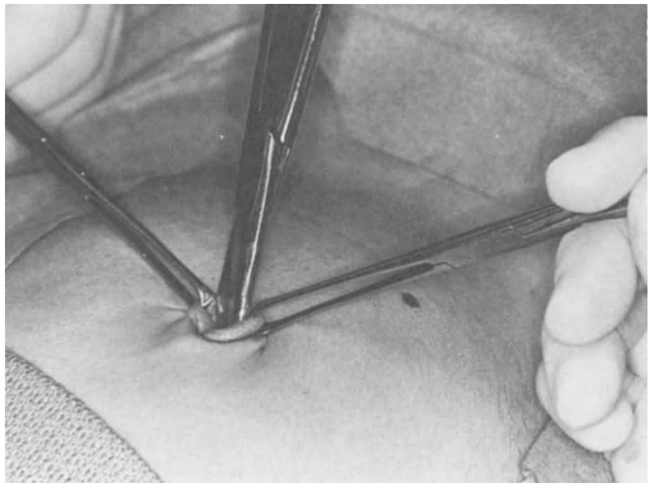

FIGURE 4-8. Exposure of the deep fascia using the Halsted spreading maneuver.

and enlarge the cleavage plane between the linea alba and the skin. The blades of the scissors are separated, using the Halsted spreading maneuver, for blunt dissection of connective tissue fibers found between the skin and deep fascia (Fig. 4-8).

Incision of Fascia and Placement of Sutures

The exposed linea alba is lifted with a right-angle skin hook, as proposed by Reyner (personal communication, 1984). The fascia is then grasped with a Kocher clamp applied on the superior or inferior fascial slope resulting from the application of the hook. A second Kocher clamp is applied on the opposite slope. The fascia is raised with the clamps so as to separate the abdominal wall from the bowel and minimize the possibility of bowel injury. The fascia is then incised transversely between the clamps while maintaining fascial elevation (Fig. 4-9). The incision need not be greater than a few millimeters. The fascial incision is enlarged, by spreading a hemostat, to accommodate the

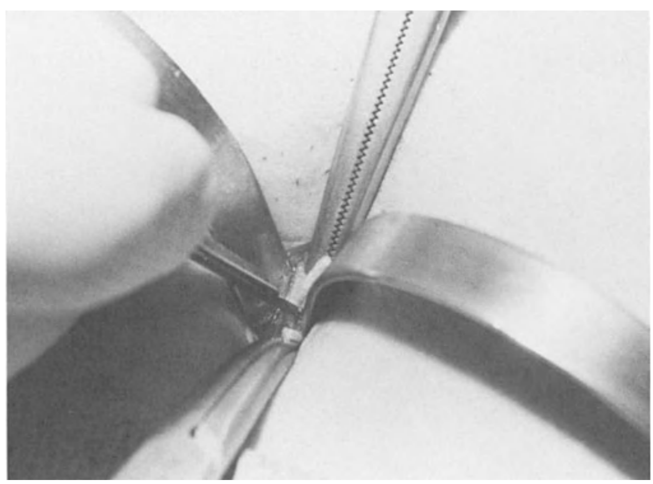

FIGURE 4-9. Incision of the deep fascia.

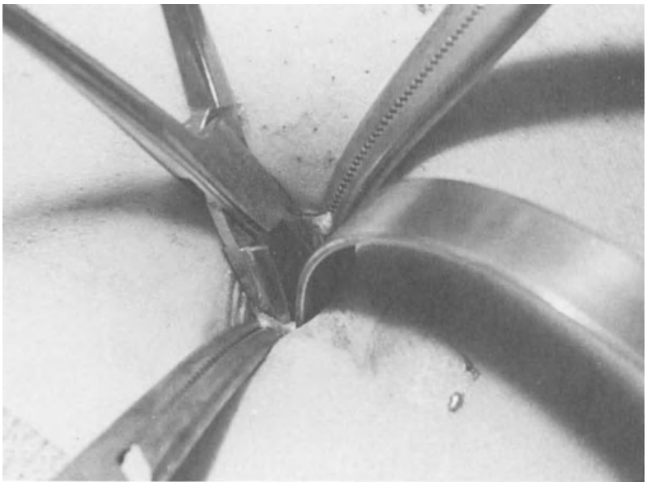

FIGURE 4-10. Placement of the S-shaped retractor flat end into the fascial incision.

laparoscopy cannula. The flat end of the S-shaped retractor is introduced into the incision to guide suturing of the fascia (Fig. 4-10). A suture of adequate tensile strength attached to a small strong needle is passed through each fascial edge and tagged.

A transverse incision in the fascia is preferred to a longitudinal incision. The latter promotes formation of an airtight seal; the former does not. The laparoscopy cannula is in an oblique position during most manipulations, and as such, the cone of the cannula interfaces with the two fascial edges of a transverse incision at different levels, creating a mechanical seal. This sealing arrangement does not occur with a longitudinal incision.

Entering the Peritoneal Cavity

Usually the peritoneum is entered when the fascial gap is enlarged by spreading a hemostat (Fig. 4-10). In this case the second retractor is introduced into the peritoneal cavity. The abdominal wall is raised with both retractors so as to confirm entry into the peritoneal cavity by viewing bowel and omentum (Fig. 4-11). If the peritoneum had

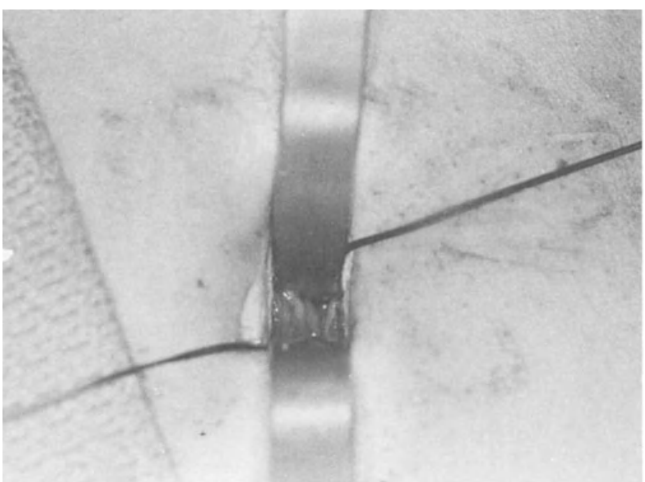

FIGURE 4-11. Peritoneal entry confirmed through viewing bowel and omentum.

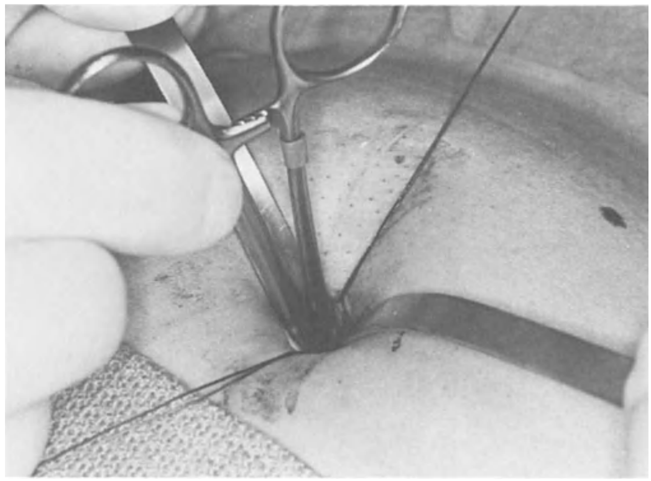

FIGURE 4-12. Peritoneal entry with a gentle thrust of a small hemostat.

not been entered, it is exposed and placed under tension by the two retractors and then entered with a gentle thrust of a small hemostat (Fig. 4-12). The hemostat is spread open, one of the retractors is placed in the abdomen between the open jaws of the hemostat, and peritoneal entry is confirmed as described. The peritoneum may resist yielding to pressure from the hemostat. In this case, the peritoneum is lifted with two clamps, exteriorized, and incised carefully to avoid trauma to the bowel.

Insertion and Fixation of the Cannula

The open laparoscopy cannula is prepared for insertion by sliding the cone sleeve over the shaft and locking the cone in a position appropriate for the individual thickness of the abdominal wall. The cannula is then gently introduced into the abdomen between the guiding S-shaped retractors (Fig. 4-13).

Gentle inward pressure is maintained on the cannula to prevent it from being displaced into the preperitoneal space during subsequent manipulations. The retractors

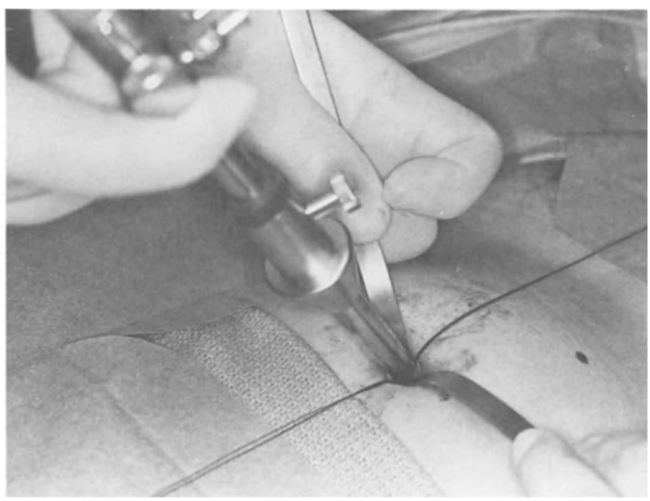

FIGURE 4-13. Introducing the open laparoscopy cannula into the abdomen, guided by the S-shaped retractors.

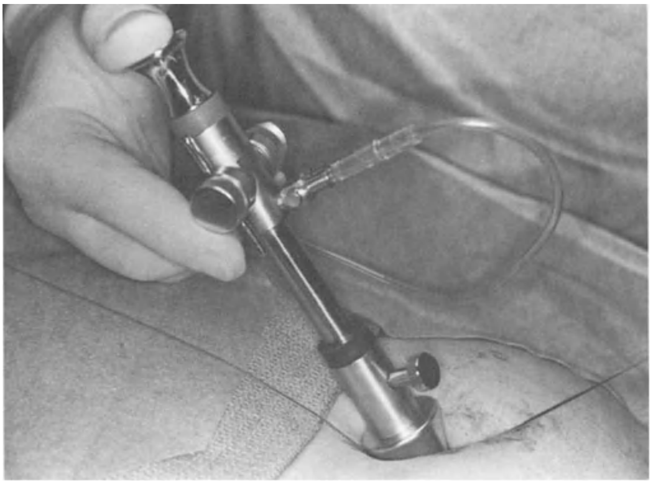

FIGURE 4-14. Gentle inward pressure maintained on the cannula.

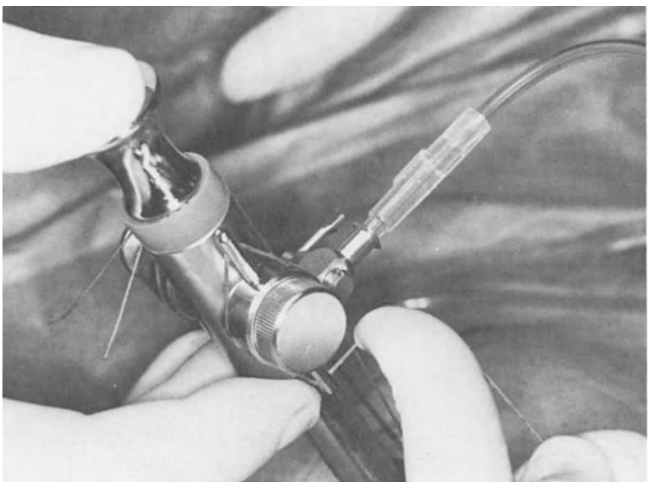

FIGURE 4-15. Threading the fascial tag sutures into the V-shaped suture holders of the cannula.

FIGURE 4-16. Creation of an airtight seal using the open laparoscopy cannula.

are removed, the insufflation line is connected to the cannula's valve, and gas is allowed to flow through the cannula into the abdomen (Fig. 4-14).

The tag sutures, previously placed into the fascial edges, are pulled upward and threaded into the V-shaped suture holders of the cannula so as to create firm tension on the suture (Fig. 4-15). This maneuver anchors the cannula to the abdominal wall and pulls the fascia firmly against the cone to provide an airtight seal (Fig. 4-16). The blunt obturator is withdrawn to allow more rapid flow of the gas.

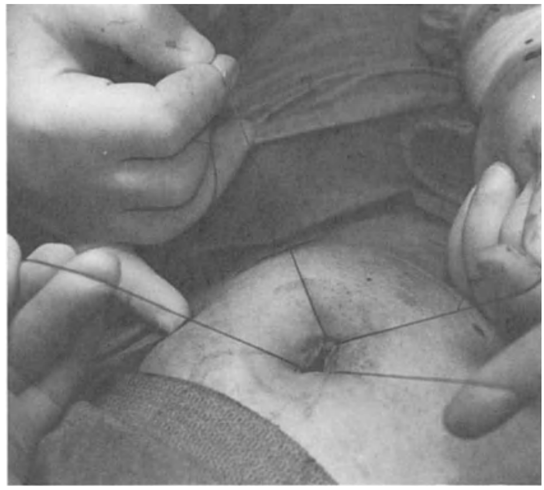

FIGURE 4-17. Positioning the superior and inferior fascial tag sutures in parallel alignment.

Performing the Laparoscopic Procedure and Closing the Abdominal Incision

The laparoscope is introduced through the cannula and the intended procedure is performed. When the procedure is completed, the distended abdomen is deflated and the cannula withdrawn. The peritoneum is not closed. The fascia is approximated using the previously placed tag sutures. These sutures are positioned in parallel alignment (Fig. 4-17). A square knot is tied on one side (Fig. 4-18), the tied suture is pulled against the fascia, and a second knot is set on the opposite side (Fig. 4-19). Additional sutures are placed as indicated. Loose approximation of the skin leads to an excellent cosmetic result (Fig. 4-20).

Operative and Recovery Times

Given a comparable degree of expertise, open and closed laparoscopy require substantially the same amount of time to perform. The recovery time is also identical.

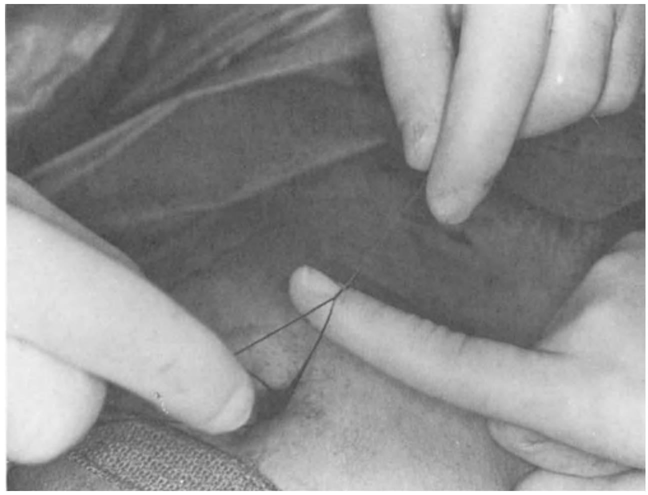

FIGURE 4-18. Tying a knot, combining the tag sutures on one side of the fascia.

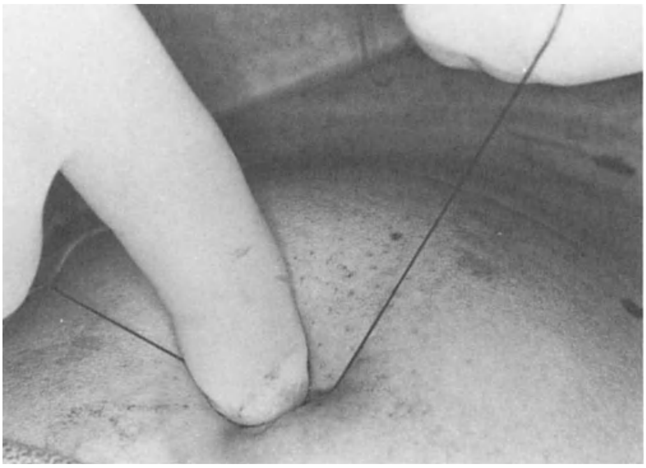

FIGURE 4-19. Setting a knot, combining the tag sutures on the opposite side of the fascia.

Routine use of either procedure improves competence and reduces operative time.

Contraindications

Contraindications of open laparoscopy are limited to conditions where creation of a pneumoperitonéum is considered harmful—mostly diseases associated with acute cardiorespiratory distress or significant chronic disability. The presence of an abdominal hernia is not a contraindication, as the maximum intraabdominal pressure obtained at laparoscopy is less than that associated with coughing or sneezing.

Complications

The complications of the open laparoscopic entry method are those also reported with an umbilical minilaparotomy. They include wound infection and small bowel injury. In a series of more than 1000 consecutive cases performed by the author and ten other surgeons in the same hospital, the incidence of minor wound infection was 0.6% and that of small bowel incisions was 0.1%.[6] No additional cases of bowel injury were noted in our series of 2000 cases, thus we have observed a bowel injury incidence of approximately 0.5 per 1000. Penfield[7] surveyed 10,840 open laparoscopy procedures per-

FIGURE 4-20. Cosmetic result following skin approximation.

formed by 18 gynecologists; the incidence of wound infection was 1.6 per 1000 and that of bowel laceration 0.5 per 1000.

Previous studies have reviewed the complications associated with open and closed laparoscopy[8,9] with the conclusion that the use of open laparoscopy eliminates the potential risks or actual complications of failed laparoscopy attempts, inappropriate gas insufflations, gas embolism, gastrointestinal puncture, bladder or pelvic kidney puncture, major vessel injury, and postoperative herniations. However, good training and experience as well as the use of proper technique and instrumentation lower the probability of major complications with either the closed or the open method of laparoscopy.

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5
Ectopic Pregnancy

HARRY REICH

Various laparoscopic techniques can now be used to treat tubal ectopic pregnancy. With the use of sensitive radioimmunoassays for the β-subunit of human chorionic gonadotropin (β-hCG) and high-resolution ultrasonography, most tubal gestations are unruptured at diagnosis. Laparotomy with salpingectomy has been the "gold standard" for treatment of tubal pregnancy during this century and may remain so for some practitioners. Such laparotomy approaches are not addressed in this chapter. The relative merits of a conservative approach (salpingotomy or partial salpingectomy) versus radical treatment (salpingectomy or salpingo-oophorectomy) are also not discussed. Nonsurgical management, however, is evaluated because of its potential as an adjunct to laparoscopic surgery.

Major advantages of the laparoscopic approach include reduced hospital stay, return to full activity within 1 week of surgery, and a reasonable subsequent intrauterine pregnancy rate. Average hospital stay during laparotomy management is 5.2 days, whereas a laparoscopic approach frequently results in hospitalization of less than 24 hours.[1] In addition, laparoscopy prevents drying of both the parietal and visceral peritoneum and limits the risk of infection, both of which may result in the reduction of postoperative adhesions commonly associated with laparotomy. Blood loss and cutaneous scarring associated with an abdominal incision are also avoided.

Salpingotomy implies opening a fallopian tube by an incision, whereas salpingostomy in most cases infers making a new opening designed to remain open. Some authors use the term salpingostomy to mean that the tubal incision is left open after evacuating its contents and is closed later by secondary intention. These surgeons use salpingotomy to imply primary surgical closure of the tube. The term *salpingotomy* is used throughout this chapter for conservative removal of products of conception through an incision in the tube, whether the tube is later left open or reapproximated.

Following the 1980 report by Budowick et al.,[2] there was controversy regarding whether most tubal pregnancies grow inside the tube or in the extraluminal loose adventitial tissue between the tubal serosa and muscularis. An extraluminal location has rarely been reported by surgeons performing conservative procedures for tubal pregnancy, however, and it can be inferred that most tubal pregnancies grow inside the tube. The special problems associated with trophoblast growth in the extraluminal space are addressed.

History

Reports of laparoscopic treatment using salpingectomy and salpingotomy have been appearing with increasing frequency.[3–20] In 1973 Shapiro and Adler[3] described laparoscopic partial salpingectomy using electrocoagulation, and Soderstrom's report followed in 1975.[4]

One hundred cases of salpingectomy were reported by Dubuisson in 1987[15] using thermocoagulation and transection of the isthmus, mesosalpinx, and tuboovarian ligament. Two laparotomies, one for severe adhesions and the other for a large retrouterine hematocele, were necessary. Hemoperitoneum of more than 100 ml was present in 12 cases, the tube was ruptured in 32 cases, and an ampullary pregnancy larger than 3 cm in diameter was present in 42 cases. The average operating time was 37 minutes, with more recent procedures taking 15–40 minutes. Average postoperative stay was 2 days, and no immediate or delayed postoperative hemorrhage or fever occurred.[15]

Bruhat's group reported 321 tubal pregnancies in 295 women treated by laparoscopic salpingotomy from 1974 to 1984. There were 15 failures (5%), i.e., incomplete removal of trophoblast; seven were treated with a second laparoscopic procedure and eight by laparotomy. Of 118 patients desiring pregnancy and followed for more than 12 months, 76 (64%) had an intrauterine pregnancy, 5 after laparoscopic treatment of a second ectopic, and 26 (22%) had a subsequent ectopic pregnancy. More importantly, 53 of 62 women (86%) without a history of infertility and 23 of 56 (41%) with a history of infertility had an intrauterine pregnancy. Eleven of 24 women (46%) had an intrauterine pregnancy after removal of an ectopic gestation from their sole remaining tube, but 7 (29%) in this group had a second ectopic pregnancy.[12]

DeCherney et al.[19] reported the largest American series: 79 ectopic pregnancies successfully treated via laparoscopy. Of 69 women desiring conception, 26 (38%) achieved a viable pregnancy, with a recurrent ectopic rate of 10% (7 of 69).[19]

In the author's experience, 54 tubal pregnancies have been managed laparoscopically, including four with rupture. Since 1983 laparoscopic procedures have been the author's only method of managing tubal pregnancy (last 53 cases). Johns and Hardie[11] reported similar success using laser laparoscopy; and we have presented a combined series of 109 consecutive tubal pregnancies treated with a laparoscopic technique.[20] Of 38 women desiring conception, 19 have had documented intrauterine pregnancy, with two resulting in spontaneous abortion. Of 33 tubes tested after salpingotomy, 31 were patent. The American Fertility Society has provided a classification scheme for tubal pregnancies, shown in Table 5-1.

Instrumentation

Laparoscopic electrosurgical techniques are ideally suited for tubal pregnancy surgery. Bipolar forceps, which permit high-frequency low-voltage current (25–50 watts) to be passed through its jaws, are used for desiccation of the proximal tube, its mesosalpinx, and in rare cases both the infundibulopelvic ligament with enclosed ovarian vessels and the uteroovarian ligament.[21] (Fig. 5-1).

A 3-mm knife electrode is an excellent instrument for opening a fallopian tube with a salpingotomy incision. The tips of laparoscopic scissors can be used in a similar fashion, as can the CO_2 laser. The knife electrode is connected to a low-voltage electrosurgical generator, and unipolar pure cutting current (40–80 watts) is used. On a Valleylab (Boulder, CO) SSE2L unit with a low-power attenuator control, which limits all three generator outputs to less than 100 watts and less than 600 volts peak, low-power settings of 7–10 produce 50–75 watts of power. Without a low-power attenuator control, a cutting current setting of 2 on the SSE2L unit produces 75 watts; higher settings should be avoided (Table 5-2). Pure cutting current is critical both for precision and to minimize the low-grade thermal coagulation zone in surrounding tissue. Coagulation current is used only for coagulating specific blood vessels or hemorrhagic ovarian cysts.

TABLE 5-1

THE AMERICAN FERTILITY SOCIETY CLASSIFICATION OF TUBAL PREGNANCIES

Patient's Name ____________________ Date ________ Chart # ________

Age ______ G ______ P ______ Sp Ab ______ VTP ______ Ectopic ______ Infertile Yes ______ No ______

Other Significant History (i.e. surgery, infection, etc.) ____________________

____

HSG ________ Sonography ________ Photography ________ Laparoscopy ________ Laparotomy ________

TUBAL PREGNANCY

	Right	Left	Contralateral Tube & Ovary
Infundibular	______	______	Normal ______ Absent ______
Ampullary	______	______	Abnormal ______
Isthmic	______	______	______
Interstitial	______	______	______
Size (cm)	______	______	______

Treatment (Surgical Procedures):

Laparoscopy ______
- No Surgery ______
- Surgery ______
  - Expression ______
  - Linear Salpingostomy ______
    - Sharp Dissection ______
    - Laser ______
    - Cautery ______

Laparotomy ______
- Linear Salpingostomy ______
  - 1° Closure ______
  - 2° Closure ______
- Segmental Resection ______
  - 1° Anastomosis ______
  - 2° Anastomosis Planned Yes ______ No ______

Other: ____________________

____

____

____

Prognosis for Conception & Subsequent Viable Infant*

______ Excellent (> 75%)

______ Good (50-75%)

______ Fair (25%-50%)

______ Poor (< 25%)

* Physician's judgment based upon adnexa with least amount of pathology.

Recommended Followup Treatment: ____________________

____

____

Additional Findings: ____________________

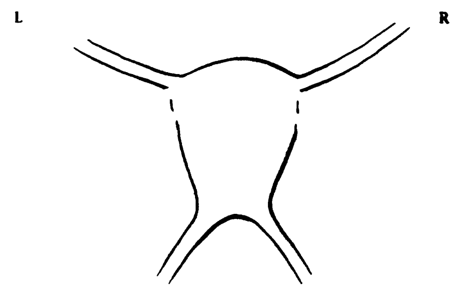
____

____

____

____

DRAWING



For additional supply write to:
The American Fertility Society
2140 11th Avenue, South
Suite 200
Birmingham, Alabama 35205

Property of
The American Fertility Society

From The American Fertility Society: The American Fertility Society classification of adnexal adhesions, distal tubal occlusion, tubal occlusion secondary to tubal ligation, tubal pregnancies, Mullerian anomalies and intrauterine adhesions. Fertil Steril 49:944, 1988. Reproduced with permission of the publisher, The American Fertility Society.

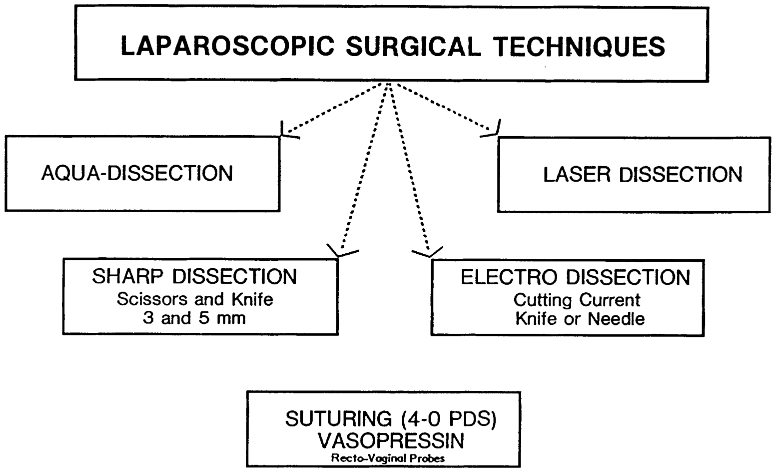


FIGURE 5-1. Laparoscopic surgical techniques.

TABLE 5-2. Wolf knife electrode

	Valleylab SSE2 electrosurgical generator			SSE2 with low-power attenuator		
Setting	Cut	Blend	COAG	Cut	Blend	COAG
0	0	0	0	0	0	0
1	0	0	0	0	0	0
2	70	35	20	0	0	0
3	**150**	85	30	5	0	0
4	**195**	**115**	40	15	2	0
5	**220**	**145**	55	25	5	2
6	**250**	**160**	65	30	8	3
7	**280**	**175**	**75**	40	10	5
8	**310**	**190**	**90**	50	12	7
9	**340**	**220**	**100**	60	15	9
10	**370**	**260**	**120**	70	20	10

Power is in watts. The apparatus is monopolar. Settings in boldface should be avoided.

Throughout most laparoscopic procedures, a suction–irrigator–dissector is essential to evacuate smoke, remove clots, retract, atraumatically elevate the tube or ovary, irrigate the tube and cul-de-sac, and develop surgical planes (aquadissection). The Aquapurator with a solid distal tip made by Wisap (Sauerlach, West Germany) fits this requirement. Viable products of conception, without surrounding organized blood clots, can often be evacuated completely from a fallopian tube using a suction–irrigator; trophoblastic tissue with surrounding blood clots can be irrigated out of the tubal lumen using the hydraulic pressure of the fluid irrigant.

A laser beam can be used to open the tube and perform a laparoscopic colpotomy. However, the laser is often not practical for nonscheduled (emergency) surgery in most hospitals. The insurance policies of many hospitals mandate that a separate "laser nurse" be present for laser surgery in addition to the necessary scrub and circulating nurses, often an impossibility in the middle of the night.

Thermocoagulation or endocoagulation using specialized equipment available from Wisap enable coagulation of the involved tube at a temperature of 100°–120°C. Both salpingectomy and salpingotomy can be performed with this equipment (see Chap. 2).

Basic Techniques

All operations are performed under general anesthesia with endotracheal intubation. Steep Trendelenburg position (20°–30°) is helpful, as is a high-flow CO_2 insufflator capable of delivering CO_2 at more than 3 L/min. Hysteroscopy using CO_2 is usually performed at the same time as peritoneal insufflation, when the diagnosis is not in doubt, followed by insertion of a Cohen cannula into the uterus for tubal lavage and uterine manipulation. A 10-mm laparoscope is inserted through a vertical intraumbilical incision, and lower-quadrant 3- and 5-mm puncture sites are made just below the pubic hairline and medial to the inferior epigastric vessels. The 5-mm puncture site is made on the patient's left to avoid mechanical malfunctions from the Aquapurator, the "workhorse instrument" in most cases, which is placed on a sterile table behind the surgeon and connected by tubing to wall suction and to a pressurized source of Ringer's lactate irrigant. The tubing of the Aquapurator, which is manipulated with the surgeon's left hand, would frequently become kinked if it were stretched across the abdomen to a right-sided abdominal puncture site. It is important for the operator to be consistent with incisions, regardless of the pathology involved; it results in a reproducible procedure with resultant reduction in intra-operative decision-making.

A video camera with beam splitter attached to the laparoscope permits much of the procedure to be performed with the surgeon watching a video monitor. Beam splitters supply 80–90% of available light to the video monitor, providing an excellent picture. However, operating while viewing the surgical field through the laparoscope produces considerable eyestrain. Beam splitters have been developed that supply more light to the operator's eye, thereby, easing the problem of eye strain. Devices can be used to stabilize the laparoscopic trocar sleeve, allowing the surgeon to operate with two hands, each on a lower quadrant instrument.

Any adhesions on the contralateral tube are usually treated during the same laparoscopic procedure. At the close of each procedure, excess CO_2 is expelled and 1–2 L of Ringer's lactate left in the peritoneal cavity to separate the surfaces of pelvic organs during early healing. Postoperatively, Rh immunoglobulin (RhIg) is administered to unsensitized Rh-negative patients with an ectopic pregnancy (50 μg RhIg is usually adequate to prevent sensitization). To document successful treatment, quantitative β-hCG titers are obtained weekly until negative.

Evacuation of Hemoperitoneum

Usually the 5-mm suction–irrigator is sufficient to evacuate the hemoperitoneum, including large clots that may require much manipulation and clearing of the instrument. In cases of tubal rupture the patient may be unstable and hemoperitoneum and clots may be excessive. For these cases, it is best to insert an 11-mm left lower quadrant trocar (similar to the umbilical trocar) and thread the wall suction tubing directly through it (Seamless [Wallingford, CT] surgical connecting tubing with an internal diameter of 0.25 inch). Wells Johnson Co. (Tucson, AZ) aspiration tubing, with an internal diameter of 0.281 inch, can also be attached just above the trumpet valve of an 11-mm trumpet valved trocar sleeve. By aspirating the larger clots directly, one can avoid obstructing the suction–irrigation device. Visualization of the site of rupture or active bleeding can thus be rapidly obtained and treatment initiated. If prompt control is unattainable, immediate laparotomy should be considered.

Laparoscopic Salpingectomy

Laparoscopic salpingectomy is the method of choice when future fertility is not desired or in cases of rupture. Other indications for salpingectomy are tubal pregnancy following sterilization failure, tubal pregnancy in the blindly ending distal tubal segment resulting from partial salpingectomy, requested sterilization, and hemorrhage following salpingotomy.

Following evacuation of a hemoperitoneum, Kleppinger bipolar forceps and the laparoscopic hook scissors are introduced successively to coagulate and cut the tube and its mesosalpinx. An Endoloop ligature (Ethicon, Somerville, NJ) can also be used around the distended tube to safely perform a salpingectomy (Fig. 5-2).

The segment of tube with its enclosed ectopic pregnancy is then removed from the peritoneal cavity through the 11-mm umbilical trocar sleeve using forceps placed through the umbilical incision. The laparoscope and sleeve are then reinserted and final portion of the tube is within the trocar sleeve, the laparoscope, forceps, and sleeve are removed in one motion, resulting in either complete removal of the tube or removal of a portion of tube, which can then be grasped with a hemostat and teased out through the umbilical incision. The laparoscope and sleeve are then reinserted and final inspection performed. Removal of a tube in the manner just described often results in a "milking" process whereby products of conception are extruded from the tube as it is being pulled through the trocar sleeve. The

FIGURE 5-2. (1) Coagulation of the tube adjacent to a tubal pregnancy using bipolar forceps. (2) Coagulation of mesosalpinx. (3) Division of mesosalpinx using laparoscopic scissors. (Reprinted from The Journal of Reproductive Medicine, ref. 20, with permission.)

products of conception remain in the peritoneal cavity, from where they are removed with the Aquapurator or biopsy forceps. Salpingotomy (ampullotomy) with aspiration of the products of conception reduces its volume before extraction, i.e., extraction of the tube through the umbilical trocar sleeve, and thus prevents a "milking" effect.

The umbilical extension technique developed by the author is a better method. The umbilical incision is always made inside the umbilicus, overlying the area where skin, deep fascia, and parietal peritoneum of the anterior abdominal wall meet. This incision can be enlarged using the operating laparoscope with scissors in the operating channel. The tip of the laparoscope is placed 1 cm from the tip of the trocar sleeve, which is then gently removed from the peritoneal cavity. The peritoneum is first visualized and can then be incised downward in the midline with the scissors in the operating channel of the operating laparoscope. Next, deep fascia is identified and incised to add another 1–2 cm to the incision. Finally, the skin incision inside the umbilicus can be extended upward to incorporate the superior wall of the umbilical fossa.

The products of conception can also be removed through a lower quadrant 5-mm or 11-mm trocar sleeve using the instruments as described in Chapter 2. It is rarely necessary to perform a colpotomy or morcellation. Colpotomy can be performed vaginally if needed. Alternatively, colpotomy can be made using laparoscopic techniques: a sponge at the end of a ring forceps is placed just behind the cervix to identify the posterior cul-de-sac. A second sponge or probe is placed in the rectum and then removed; this step confirms the anatomic relation of the rectum to the posterior vagina and thus serves to rule out any abnormal tenting of the rectum in this area. A 1-mm spot size CO_2 laser beam with power set at 25–35 watts superpulse or 60 watts continuous is then directed through the laser laparoscope to make a transverse colpotomy incision directly over the posterior fornix sponge. Alternately, the 3-mm knife electrode at 70 watts cutting current can be employed. Thereafter the usually large tubal pregnancy can be pushed through the incision made from above, or pulled through from below either with laparoscopic biopsy forceps or the surgeon's fingers, all under direct visualization. (See also Chapter 16.)

Laparoscopic Partial Salpingectomy (Midtube Resection)

Laparoscopic partial salpingectomy can be performed for salpingotomy failure, ruptured tubal pregnancy, isthmic ectopic pregnancy, distal interstitial ectopic pregnancy, chronic tubal pregnancy, and same-side recurrent tubal pregnancy. Kleppinger bipolar forceps are used to coagulate the tube on each side of the distention made by the tubal pregnancy. The resultant desiccated areas are then divided with laparoscopic hook scissors. The mesosalpinx supplying the involved tubal segment is next coagulated and divided, and the tube segment removed from the peritoneal cavity through the 11-mm umbilical trocar sleeve or by laparoscopic colpotomy.

With another technique, a Roeder loop ligature (Endoloop; Ethicon) can be placed around the tube segment with its enclosed ectopic pregnancy. This loop is inserted into a special applicator and introduced into the pelvis through the 5-mm trocar sleeve (see Chap. 2). The tube and its mesosalpinx are divided with laparoscopic scissors. Should the Endoloop ligature slip, the pedicles can always be regrasped and either another Endoloop ligature placed or complete hemostasis obtained using bipolar forceps (Fig. 5-3).

Laparoscopic Salpingotomy

Tubal preservation should be attempted in all cases of tubal pregnancy surgery where future fertility may be desired, vital signs are stable, and gross rupture is not evident. Salpingotomy is the procedure of choice for tubal preservation and can be performed easily, quickly, and safely. It is faster than

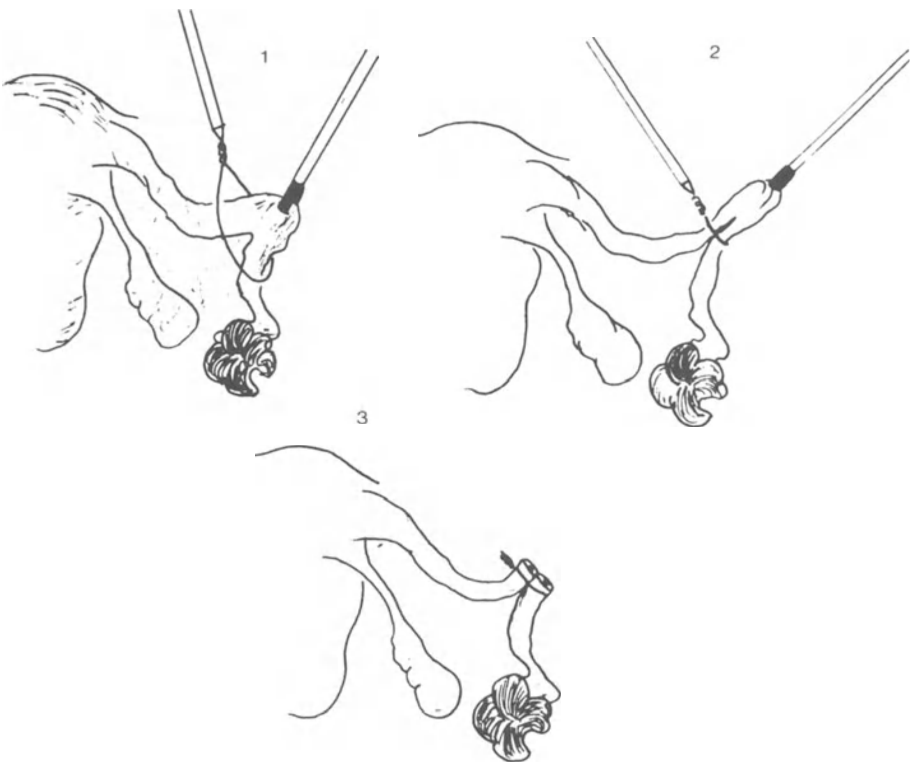


FIGURE 5-3. (1) Placement of the Endoloop around a tubal pregnancy. (2) Tightening of the Endoloop knot using a pusher. (3) End result after excision of the tube with its enclosed pregnancy. (Reprinted from The Journal of Reproductive Medicine, ref. 20, with permission.)

partial salpingectomy with immediate anastomosis and more economical than partial salpingectomy with delayed anastomosis as it saves the patient a future laparotomy procedure. As most tubal pregnancies occur in the ampulla, isthmic tubal pregnancies are addressed separately, as is the rare ampullary tubal pregnancy whose main component is in the extraluminal space.

Following evacuation of the hemoperitoneum, the tuboovarian complex is mobilized usually with the aid of the Aquapurator. In many cases a "phlegmon" of tube–ovary exists that should be separated using the Aquapurator. The mesosalpinx is infiltrated with a dilute vasopressin solution (Pitressin; Parke Davis, Morris Plains, NJ) as first described by Bruhat's group.[12] A mixture of 20 units (one ampule) in 50 ml of normal saline works well, though more dilute or more concentrated solutions may be used. Either a 3- or a 5-mm injection and puncture cannula can be used through the lower quadrant trocar sleeves. Alternatively, a 22-gauge spinal needle can be inserted directly through the skin at pubic hairline level usually just lateral to the inferior epigastric vessels. Care must be taken at initial insertion into the mesosalpinx to avoid direct injection into the blood vessels; i.e., the serosa should be gently punctured prior to infiltration of the solution. Thereafter 10–20 ml of the solution can be infiltrated, which should cause a grossly visible swelling in the mesosalpinx.

The pharmacologic effect of vasopressin persists for approximately 2 hours and is probably sufficient to allow physiologic hemostasis to occur. It cannot be overemphasized that great care is necessary during penetration of the mesosalpingeal peritoneum to avoid vessel laceration or intravascular injection, which can cause arterial hypertension. Extravascular injection itself can induce a moderate increase in the arterial blood pressure or a moderate bradycardia. To the author's knowledge, no short- or long-term complications from vasopressin have been reported during laparoscopic procedures.

The 3-mm knife electrode is used to make a 1- to 2-cm incision in the antimesenteric border over the point of maximal tubal dilatation using cutting current (50–80 watts) through a 3-mm knife electrode. Alternatively, the CO_2 laser at 25–35 watts superpulse can be used. Tubal layers can often be identified, i.e., serosa followed by stretched out muscularis–mucosa, prior to entering the tubal lumen. On occasion, a blood clot can be expressed from the extraluminal space prior to separately opening the muscularis–mucosa.

Often following salpingotomy incision products of conception begin to extrude. At this point, the Aquapurator is used to suction loose, friable products of conception that may be present with viable ectopic pregnancies. In other cases, where a blood clot has formed firmly around the products of conception, irrigation from the Aquapurator can be used to mobilize the clot with its enclosed gestational tissue. On occasion, it is necessary to insert atraumatic grasping forceps into the tube to mobilize the products of conception with a spreading motion prior to using the Aquapurator to effect expulsion. These same forceps are also used to check the inside of the tube after evacuation. Finally, toothed biopsy forceps are necessary in some cases to grasp and tease out products of conception closely adherent to the tubal wall.

Removal of the products of conception from the peritoneal cavity is accomplished as previously described using the 11-mm umbilical trocar sleeve and the operating laparoscope with enclosed biopsy forceps. At times the products of conception can be reduced to smaller pieces using biopsy forceps and the Aquapurator (Fig. 5-4).

The tube is then irrigated both distally with the Aquapurator and proximally through a cervical Cohen cannula. The salpingotomy is usually left open; but if the defect is large or marked eversion of mucosa occurs, a 4-0 polydioxanone suture (PDS: Ethicon Z-420, Somerville, NJ) can be placed and tied either with instruments inside the peritoneal cavity or outside the peritoneal cavity with a modified half-hitch, that is then slipped down to the tube.[22] Should bleeding from the tubal edge or implantation site be present following evacuation of the products of conception, compression with grasping forceps should be attemped prior to resorting to either electrosurgical coagulation, laser, or a suture. Frequently, 5 minutes of pressure at the salpingotomy edge results in complete hemostasis. In other instances, lifting the adnexa (tube–ovary) above the pelvic brim—in effect kinking the mesosalpingeal vessels—gives a similar result.

If uncontrollable hemorrhage occurs during evacuation of the ampulla, the ampulla can be loosely ligated with an Endoloop as described by Semm.[18] After 5–10 minutes, during which time the cul-de-sac and the subphrenic space are irrigated and evacuated, the ligature is released. In most cases the bleeding subsides. If not, selected areas in the mesosalpinx can be suture ligated; or if the contralateral tube appears normal, salpingectomy or partial salpingectomy can be performed as previously described.

Fimbrial Evacuation of Tubal Pregnancy

Fimbrial evacuation, tubal aspiration without salpingotomy, and tubal abortion without salpingotomy all refer to the technique of removing products of conception at or near the fimbrial end of the tube using either suction or grasping forceps and, on occasion, using grasping forceps to gently push the products of conception toward the fimbrial end. In some cases tubal abortion is already in progress.

Of 15 failures (incomplete removal of trophoblast) among 321 tubal pregnancies treated by Bruhat et al., four occurred in the

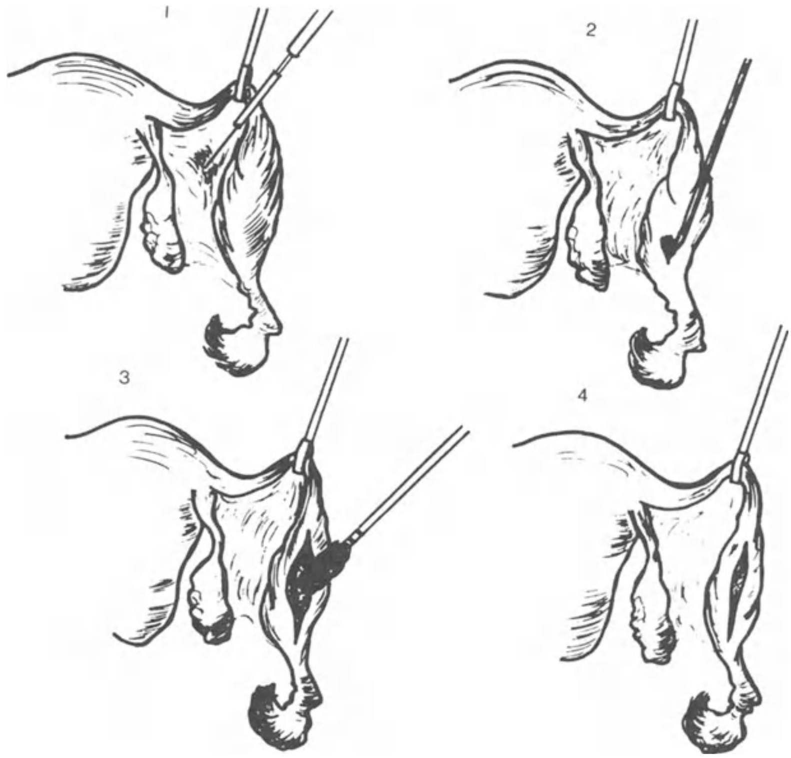


FIGURE 5-4. (1) Vasopressin injection into the mesosalpinx. (2) Salpingotomy incision with knife electrode electrosurgery. (3) Evaluation of products of conception from the tube. (4) Salpingotomy incision left open at the end of the procedure. (Reprinted from The Journal of Reproductive Medicine, ref. 20, with permission.)

tubal abortion group.[12] In Bruhat's et al.'s 1980 report of 60 tubal pregnancies,[7] three failures were noted following 17 cases of tubal aspiration. Nevertheless, the same group in 1986 reported 15 fimbrial tubal pregnancies occurring in 118 patients desiring future fertility: twelve of the women had subsequent intrauterine pregnancies (80%), and three had recurrent ectopic pregnancies (20%).[12]

Concern regarding incomplete removal of trophoblast and increased tubal damage has resulted in the condemnation of fimbrial evacuation of a tubal pregnancy using either laparoscopic or laparotomy techniques. The findings of Sherman et al.[23] may encourage the laparoscopic surgeon to reconsider this method. Through a laparotomy series Sherman's group successfully expressed 31 unruptured tubal gestations through the fimbriated end of the tube.[23] Of 27 women followed for more than 3 years, 25 later conceived, resulting in 23 term pregnancies, 2 spontaneous abortions, and no repeat ectopic pregnancies.[23]

If most ampullary tubal pregnancies rapidly invade the tubal wall and grow in the loose connective tissue between mucosa and serosa, milking the ectopic pregnancy out of the fimbria would cause further tubal destruction. The author has not seen a high incidence of extraluminal tubal pregnancies and thus will in the future consider treating selected cases of possible incomplete tubal abortion via laparoscopic fimbrial suction evacuation. In six cases the Aquapurator has been used to suction and irrigate products of conception from within the distal fallopian tube with no early or late complications.

Special Situations

Isthmic Ectopic Pregnancy

Ectopic pregnancy in the isthmic portion of the fallopian tube is uncommon. Twenty-two isthmic tubal pregnancies were treated by laparoscopic salpingotomy in Bruhat et al.'s 1986 report[12] of 118 women with a tubal pregnancy who desired future fertility; 12 of these women later had intrauterine pregnancies (54.5%), and 8 had a repeat ectopic pregnancy (36.4%). DeCherney and Boyers[24] concluded that segmental resection with either immediate or delayed anastomosis was the treatment of choice for isthmic ectopic pregnancy following postoperative tubal occlusion per hysterosalpingogram in three of four women who underwent isthmic salpingotomy.

Smith and co-workers[25] reported 1 year's experience at Grady Memorial Hospital, Atlanta, GA, with 20 isthmic ectopic pregnancies. Nine women underwent linear salpingotomy. In five of the six patients who had postoperative hysterosalpingography, patency of the involved fallopian tube was demonstrated; the sixth had isthmic patency but a hydrosalpinx. Four of these nine women, including one woman with contralateral tubal occlusion, have conceived.

In the series of 109 consecutive tubal pregnancies compiled by Reich et al.,[20] there were nine isthmic tubal pregnancies: Six were treated by partial salpingectomy and three by salpingotomy. No subsequent pregnancies have occurred in either group. A future laparotomy for microsurgical tubal anastomosis is always necessary following laparoscopic partial tubal resection if a solitary tube is present. This procedure may possibly be avoided by a salpingotomy approach.

Cornual (Interstitial) Ectopic Pregnancy

Cornual ectopic pregnancies are rare—in fact so rare that there are no reports to our knowledge of treatment via laparoscopy. Both Johns and this author[20] have noted isthmic tubal pregnancies bordering on cornual pregnancies, i.e., the proximal portion of the tubal dilatation caused by the ectopic pregnancy was actually in the uterine wall. These three cases were treated laparoscopically by segmental resection resulting in preservation of most of the distal portion of the tube but destruction of much interstitium, making the success of a future anastomosis unlikely. However, tubal implantation would still be possible.

The diagnosis of true interstitial ectopic pregnancy is often missed at laparoscopy. It should be suspected when the endometrial cavity is empty and both fallopian tubes look normal despite a β-hCG value indicating an existing pregnancy. Bulging or "nodularity" in the cornual area is usually present.

Methotrexate may prove to be a useful adjuvant for cornual ectopic pregnancy, and there are two reports documenting its successful use. Tanaka et al.[26] in 1982 reported a case where an interstitial ectopic pregnancy was diagnosed at laparotomy, following which the abdomen was closed and the patient treated with methotrexate. The decision to use methotrexate was based to a large extent on the patient's desire to maintain subsequent fertility potential. Hysterosalpingography following completion of therapy revealed bilateral tubal patency. Similarly, Brandes et al.[27] reported a woman with suspected gestational trophoblastic disease treated with an 8-day course of methotrexate plus citrovorum factor rescue; repeat ultrasound and later diagnostic laparoscopy revealed a right cornual pregnancy. Hysterosalpingography subsequently revealed blockage of this tube.

Extraluminal Tubal Pregnancy

In 1980 Budowick and colleagues,[2] from a series of 20 dissections of tubal pregnancies, concluded that the growing gestation rapidly penetrates the wall of the tube, and subsequently most of its growth occurs in an extratubal location between the tubal serosa and its muscularis. Stock[28] in 1985 reviewed the histopathology of 110 cases of tubal gestation and concluded that the developing tubal pregnancy was intraluminal, within the muscularis of the tube, in all but one case. Pauerstein and colleagues,[29] after a systematic gross and histopathologic study of 25 consecutive ectopic pregnancies, concluded that an intraluminal location was present in 67%. This evolving understanding of the pathophysiology of ectopic tubal pregnancy has significant clinical implications regarding management decisions.

The rarely occurring extraluminal ectopic pregnancy can be difficult to treat laparoscopically unless recognized early. In these cases, upon opening the tubal serosa over the most distended portion of the tube, products of conception may be evident but do not extrude spontaneously, as there is no surrounding muscularis. Trophoblastic tissue must be removed in pieces, with special care taken not to avulse the normal tube. Thereafter irrigation with the Aquapurator produces distention of the tube without free flow out of the fimbrial end. Should bleeding be present, the operator can err by trying to open the tube further.

In the author's experience, rarely does the surgeon enter the true tubal lumen. Occasionally, the blood clot and products of conception envelop the space between serosa and muscularis through 360°. After removing the products of conception and obtaining hemostasis with pressure, coagulation electrosurgery, or laser, the surgeon should end the procedure and follow the patient carefully with β-hCG titers. Adjuvant therapy with methotrexate may also be considered.

Ruptured Tubal Pregnancy

In the series of 109 consecutive tubal pregnancies compiled by Reich et al.[20] there were 16 cases of ruptured tubal pregnancy. Salpingectomy or partial salpingectomy was performed in 13 of these cases and salpingotomy in three. Subsequently, two women have had intrauterine pregnancies. Another woman in this group who underwent salpingectomy has since had two pregnancies in her remaining tube, both treated by laparoscopic salpingotomy.[20]

In Bruhat's series of 118 women who had tubal pregnancies treated by laparoscopic salpingotomy while still desiring fertility, a ruptured tube was present in 47.[12] Intrauterine pregnancies were later recorded in 27 of these women (57.4%) and recurrent ectopic pregnancy in 9 (19%). A ruptured tube was present in 32 of the 100 cases of laparoscopic salpingectomy reported by Dubuisson et al.[15]

Although many clinicians believe that laparoscopy may cause delay in the patient with a ruptured tubal pregnancy who is in shock, the expert laparoscopist can control bleeding as quickly as most gynecologists with laparotomy regardless of the extent of hemoperitoneum. Although only one of four women with ruptured tubal pregnancies treated by this author was in shock, all had at least 500 ml of hemoperitoneum. The woman in shock was admitted from the emergency room to the operating room. After induction of anesthesia, active bleeding was completely controlled within 5 minutes using the Kleppinger bipolar forceps to coagulate the tube and its mesosalpinx. In this case, another hour was spent evacuating the hemoperitoneum and removing the 13-week gestation tube. The patient was exceptionally stable during this part of the procedure; and after receiving 2 units of packed cells, she was discharged on her first postoperative day.

It should be emphasized that the Kleppinger bipolar forceps are a potent heavy-duty bipolar coagulator–desiccator that can easily and effectively coagulate the tube and mesosalpinx despite active arterial or venous bleeding. In fact, we have used this instrument to coagulate the ovarian vessels in more than 100 laparoscopic salpingo-oophorectomy procedures.[21]

A ruptured tubal pregnancy is almost an absolute contraindication for a conservative approach. Rarely, in cases where the contralateral tube is absent, segmental resection or evacuation of products of conception following establishment of complete hemostasis can be considered—but only by the most expert laparoscopist. In most cases it is better to "face the facts"; i.e., in-vitro fertilization is practically the only hope for an intrauterine pregnancy in these women.

Chronic Ectopic Pregnancy

Fifty cases of chronic ectopic pregnancy among 882 ectopic pregnancies (5.7%) over a 3.5-year period were reported in 1982 by Cole and Corlett.[30] This condition is usually the direct result of a tubal abortion or ruptured ectopic pregnancy in which the hemodynamic insult is subclinical and self limiting and causes an inflammatory response to surrounding structures with resultant dense adhesions and occasional abscess formation involving tube, ovary, small and large bowel, and omentum. The β-hCG level is frequently low owing to nonviable trophoblastic tissue. In the Cole and Corlett series,[30] 86% of the women had pain, 80% a mass, and 68% bleeding. Operative procedures included salpingectomy (20 cases), salpingo-oophorectomy (17 cases), and salpingo-oophorectomy with abdominal hysterectomy (13 cases). Twelve women had an infection as part of the chronic ectopic process, four with abscess formation.

We have treated two chronic ectopic pregnancies laparoscopically, one by partial salpingectomy and the other by salpingectomy.[31] The surgical techniques involved are similar to those described for laparoscopic treatment of pelvic abscess (see Chap. 8). Again, it should be stressed that acute and subacute adhesions, i.e., adhesions of relatively recent onset, are amenable to laparoscopic lysis. The key is careful blunt dissection using the Aquapurator until all structures are separated.[31] Thereafter, salpingectomy can be performed using bipolar forceps to coagulate the fallopian tube and its mesosalpinx. Intravenous antibiotics should be administered if any sign of purulent material is present. In such cases the patient should also be discharged on an antibiotic effective against *Chlamydia*.

Complications of Laparoscopic Treatment of Tubal Pregnancy

Postoperative Hemorrhage

Delayed hemorrhage can occur after laparoscopic salpingotomy, though its incidence is rare. Persistent or increasing abdominal distention, abdominal puncture site bleeding, or a low postoperative hematocrit should alert one to the diagnosis. If vital signs warrant, serial hematocrits are obtained. Another laparoscopic procedure or laparotomy with partial or total salpingectomy should then be performed.

Concern remains regarding the possibility of delayed bleeding from the salpingotomized tube following the use of vasopressin for preventive hemostasis. It should be noted that Bruhat and colleagues inserted drains in most women following laparoscopic salpingotomy with vasopressin infiltration and encountered no delayed hemorrhage.[12] We have observed delayed hemorrhage in 1 of 30 laparoscopic salpingotomy procedures, and laparoscopic salpingectomy was performed the following day.

Persistent Trophoblastic Tissue

Declining quantitative β-hCG levels are necessary to document successful conservative treatment of tubal pregnancy. Persistent tubal pregnancy has been described and implies further growth of trophoblastic tissue within the tube following conservative surgery.[32–36] In our series of 109 consecutive tubal pregnancies treated laparoscopically, one persistent ectopic pregnancy occurred and was treated with a second laparoscopic salpingotomy procedure 4 weeks later.[20] Two other women had persistent β-hCG titers; laparoscopy 4 weeks later revealed ectopic trophoblastic tissue implants on the pelvic side wall and cul-de-sac peritoneum. Treatment consisted of excision with laparoscopic biopsy forceps and CO_2 laser vaporization of their bases.

Persistent ectopic pregnancy implies the presence of chronic trophoblastic tissue within the fallopian tube following conservative management, i.e., salpingotomy or fimbrial aspiration. It should be suspected if serum levels of β-hCG are detectable 2 weeks postoperatively. Titers should be followed, thereafter, and a tentative diagnosis made if titers plateau or rise. A second laparoscopy should be performed to confirm the diagnosis and to institute appropriate treatment. At laparoscopy, a second salpingotomy procedure is usually effective. A partial salpingectomy procedure using either the Endoloop ligature or bipolar coagulation may be performed if desired.

Persistent titers of hCG do not always imply that a conservative procedure for tubal pregnancy has failed. Trophoblastic implants capable of actively secreting hCG can occur outside the fallopian tube or uterus, with no evidence of "persistent tubal pregnancy."

Persistent trophoblastic tissue has been successfully treated with methotrexate without a laparoscopic procedure.[37–39] However, laparoscopy has the advantage of documenting the location of the persistent trophoblastic tissue. Should the trophoblastic tissue be in the form of peritoneal implants, patency can be confirmed in the salpingotomized tube. Conversely, should methotrexate therapy be instituted without laparoscopic diagnosis, future hysterosalpingography revealing patent tubes should not be misconstrued as evidence supporting the benefits of methotrexate therapy.

Nonsurgical Treatment of Ectopic Pregnancy

Ectopic pregnancy can be treated successfully without surgical intervention to the tube. These methods are often used in conjunction with a diagnostic laparoscopic procedure or ultrasound. The possibility also exists of using these medical techniques in conjunction with a laparoscopic surgical intervention procedure. It is important to emphasize that any form of conservative treatment for ectopic pregnancy must show a consistent trend toward the maintenance of patent tubes. Hysterosalpingography following ectopic pregnancy surgery reveals that a normal-appearing contralateral fallopian tube is, in fact, nonpatent in a substantial number of women.[40] Thus medical treatment that results in eradication of the tubal pregnancy, but scarring or obstruction of the affected fallopian tube, should rarely be considered.

Expectant Management

Expectant management without surgical intervention can be considered if β-hCG titers are declining. Garcia and colleagues[41] reported successful expectant management in 12 of 13 patients who were followed in the hospital for a minimum of 5 days after diagnostic laparoscopy. One patient required subsequent laparotomy with salpingectomy. Hysterosalpingography confirmed patent tubes in seven of ten of these women, and six of seven had patent tubes as seen by laparoscopic examination. Three women in this study delivered term infants, 2 had spontaneous abortions, and there were no repeat ectopic pregnancies. Carp and associates[42] reported successful nonsurgical treatment of ectopic pregnancy following diagnostic laparoscopy in 11 of 14 patients. Three of these patients had later intrauterine pregnancies, and one experienced a repeat ectopic pregnancy. Adoni and colleagues[43] documented successful treatment in 11 patients without laparoscopic diagnosis.

In contrast, Haney[44] has reported bilateral tubal occlusion secondary to asymptomatic tubal gestation. Gretz and Quagliarello[45] have reported a case of ruptured tubal pregnancy that occurred despite falling serum concentrations of β-hCG. In addition, Lonky and Sauer[46] have reported an ectopic pregnancy presenting with shock and undetectable β-hCG.

As Gretz and Quagliarello[45] emphasized, the likelihood of spontaneous resorption once the trophoblast stops secreting hCG versus the likelihood of rupture is equally unknown. The clinician must view falling concentrations of β-hCG as a potentially ominous finding in a patient at risk for ectopic pregnancy. As the trophoblast stops secreting hCG, it may separate from the tubal wall, and intratubal bleeding or pressure necrosis from an intraluminal clot may promote rupture. Also, occult rupture may precede or cause the death of the trophoblast and thus produce declining β-hCG levels.

It is difficult to allow degenerating products of conception to remain in the tube when diagnosis is made by laparoscopy, especially when laparoscopic salpingotomy has proved so successful for immediate treatment and later tubal patency. The patient is subjected to a laparoscopic procedure followed by close observation often in the hospital, with a small though definite possibility of another surgical procedure. In this author's opinion, the medicolegal climate in the United States at this time probably limits "expectant management" to university hospitals with stringent protocols and extensive informed consents.

Methotrexate

Methotrexate with or without citrovorum factor can be used to treat ectopic pregnancy. Methotrexate is a folic acid inhibitor that blocks nucleic acid synthesis with resultant impairment of trophoblastic cellular growth.[47] Ichinoe and colleagues[48] have reported the successful use of methotrexate for the treatment of tubal pregnancy in 22 of 23 patients. One patient underwent emergency laparotomy for tubal rupture during her treatment course. In 10 of 19 women evaluated with hysterosalpingography, laparoscopy, or both, there was complete patency of the involved oviduct.[4] Sauer and associates[49] have reported the successful use of methotrexate in 20 of 21 women. All cases were diagnosed at laparoscopy. The one failure was transfused prior to laparotomy and partial salpingectomy; active bleeding from the distal ampulla was noted at the placental site from which the ectopic had detached and aborted. A patent involved oviduct was noted in 15 of 20 women who underwent postoperative hysterosalpingography. Methotrexate side effects, including bone marrow depression and stomatitis, were rarely noted.

The use of methotrexate therapy remains controversial, the main issue being whether patients should be exposed to potentially toxic treatment when laparoscopic salpingotomy could have been performed at the time of laparoscopic diagnosis. Remember that most investigators have used methotrexate only for early tubal pregnancies, a condition easily treated laparoscopically. Perhaps, as alluded to previously, methotrexate may prove to be the ideal adjuvant in conjunction with laparoscopic treatment of extraluminal and interstitial tubal pregnancies.

Progesterone Antagonists

The antiprogesterone compound RU 486 (Roussel-Uclaf, Paris, France) binds with high affinity to progesterone receptors to inhibit the action of the hormone. Paris and colleagues[50] used RU 486, 200 mg/day, to treat 28 women with tubal pregnancies following laparoscopic diagnosis. A second laparoscopic procedure was performed 7 days after diagnosis: in 18 cases laparoscopic salpingotomy was performed, in four cases the hematosalpinx had resolved, and in four cases laparotomy was necessary because of laparoscopic inaccessibility of the involved adnexa. It was thought that the administration of RU 486 greatly facilitated the laparoscopic salpingotomy procedure, permitting spontaneous evacuation of the products of conception following opening of the tube.

Prostaglandin $F_{2\alpha}$

Hahlin and colleagues[51] have reported local injection of prostaglandin $F_{2\alpha}$ into the oviduct and corpus luteum for termination of ectopic pregnancy. Prostaglandin $F_{2\alpha}$ (1.5

mg) was injected into the tubal wall over the ectopic pregnancy, and an identical dose was thereafter injected subcapsularly into the ovary containing the corpus luteum. All 11 patients were discharged from the hospital 1 or 2 days later. Falling titers occurred in 10 of the 11 patients. The eleventh underwent a second laparoscopy with similar prostaglandin $F_{2\alpha}$ injection 14 days after her first procedure; resolution of the tubal pregnancy occurred thereafter.

Prior to clinical studies, Hahlin and associates[52] performed in vitro evaluation of the pharmacologic effect of prostaglandin $F_{2\alpha}$ on the tubal wall, tubal arteries, and corpus luteum from six women who underwent salpingectomy and corpus luteum excision for ectopic pregnancy. In vitro administration of prostaglandin $F_{2\alpha}$ induced a marked increase in activity of the tubal muscle and pronounced constriction of the tubal artery. Prostaglandin $F_{2\alpha}$ also reduced the hCG-induced increase in progesterone production from the corpus luteum.

Transvaginal Injection Under Sonographic Control

Feichtinger and Kemeter[53] reported treatment of an ectopic pregnancy with methotrexate injection via a transvaginal puncture technique originally developed for follicle aspiration. A left ampullary tubal pregnancy was diagnosed 21 days after in-vitro fertilization and embryo transfer. The sac was punctured transvaginally 34 days after embryo replacement with a transvaginal sector-scan probe and an automated puncturing device used for follicle aspiration. After aspiration of 2 ml of fluid, 1 ml of solution containing 10 mg of methotrexate was injected into the sac. The corpora lutea on both ovaries were aspirated. β-hCG was absent from serum on day 13 after methotrexate treatment, and the patient began menstruation-like bleeding 4 days after therapy.

Robertson and associates[54] have successfully injected potassium chloride into a cornual gestational sac under ultrasound control. The contents were aspirated after cessation of cardiac activity. The cornual pregnancy resolved, allowing continuation of a concomitant intrauterine pregnancy.

Conclusion

The future is now—almost all tubal pregnancies can be treated effectively and economically with a laparoscopic procedure, and gynecologists throughout the United States are becoming comfortable with the techniques involved. Laparoscopic salpingectomy should become the procedure of choice when tubal rupture with hemorrhage has occurred or extensive tubal damage is present. However, as more than one-half of the women with ectopic pregnancies have some abnormality in the opposite tube, many have difficulty conceiving following salpingectomy. Laparoscopic salpingotomy is the preferred procedure in the stable patient, especially when the opposite tube is damaged or only one tube remains. Midtube segmental resection with later anastomosis should be reserved for salpingotomy failures in cases where the opposite tube is damaged or absent. All women who undergo conservative procedures must be followed closely to rule out the possibility of persistent trophoblast growth with resultant delayed hemorrhage secondary to residual disease.

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6
Ovarian Surgery

HARRITH M. HASSON

Traditionally, most gynecologists have refrained from performing ovarian surgery through the laparoscope, citing the following reasons for this reluctance: uncertainty about indications; fear of complications, especially hemorrhage necessitating laparotomy; fear of possibly disseminating cancer during laparoscopic management of ovarian cysts; and concern about postoperative adhesions and recurrence of the treated lesion.

Contraindications

A contraindication to the use of laparoscopic ovarian surgery is an ovary that is inaccessible or densely adherent to the bowel. Although it is possible to expose the ovary and separate it from surrounding adhesions with careful dissection using electrocautery or the CO_2 laser, there are limits to what can be accomplished with a reasonable degree of safety. Solid ovarian masses are an indication for laparotomy. However, the identity of the mass can be discovered with laparoscopic fine needle biopsy. Other contraindications include cystic ovarian masses that are suspicious for neoplasia or are found in the vascular ovarian hilum. The age of the patient or size of the cyst are not considered contraindications to pelviscopic ovarian surgery.

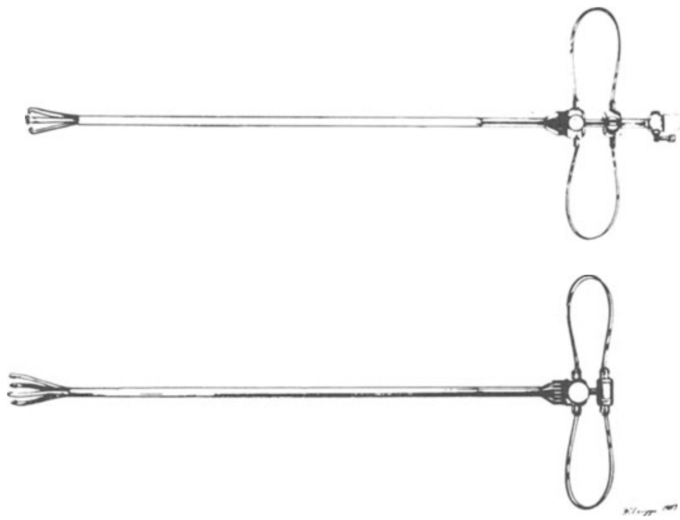
Instrumentation

Ancillary instruments extend the range of laparoscopic maneuvers and improve the technical ease of various procedures (see Chap. 2). The following instruments are considered important for successful ovarian surgery.

Multipronged grasping forceps: The three-pronged forceps can be used to hold the ovary securely throughout surgery. The ovary is released after the procedure is completed with satisfactory hemostasis. The four-pronged forceps may be used to handle delicate tissues (Fig. 6-1). Using the three-pronged forceps, the ovary can be rotated, in a clockwise or counterclockwise fashion, so as to inspect all surfaces.[1] (Fig. 6-2).

22-Gauge aspiration needle and collecting receptacle: A 21- or 22-gauge needle connected to a 5-mm tube with an inner channel 3 mm in diameter is useful for fine needle aspiration (Fig. 6-3). It is also possible to inject diluted vasopressin (Pitressin; Parke Davis, Morris Plains, NJ), one ampule (20 units) in 50 ml of normal saline, into the operative site using this needle or the finer 25-gauge needle. The aspiration needle is connected to a collecting receptacle to transmit the aspirate to the laboratory. The receptacle may be a syringe fitted into a pistol-

FIGURE 6-1. Multipronged forceps.



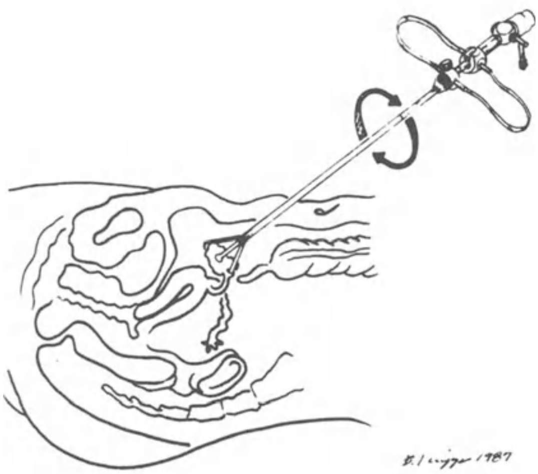


FIGURE 6-2. Clockwise rotation of the ovary with three-pronged forceps.

like handle (to increase mechanical advantage) or a Leuken tube using central wall suction (Fig. 6-4).

Suction/irrigation system: As with other types of operative laparoscopy, an efficient suction and irrigation system is essential. The irrigation channel or mode is useful for gentle blunt dissection and exposure of tissues, identification of bleeding vessels, and washings. The suction mode can be used for traction as well as for removal of fluids, gases, smoke, and so on (see Chap. 2).

Toothed biopsy forceps: This type of forceps is preferred because it cuts an adequate biopsy. It can also be used jointly with a mate to pull the lining of a cyst off the adjoining base of the ovary (Fig. 6-3).

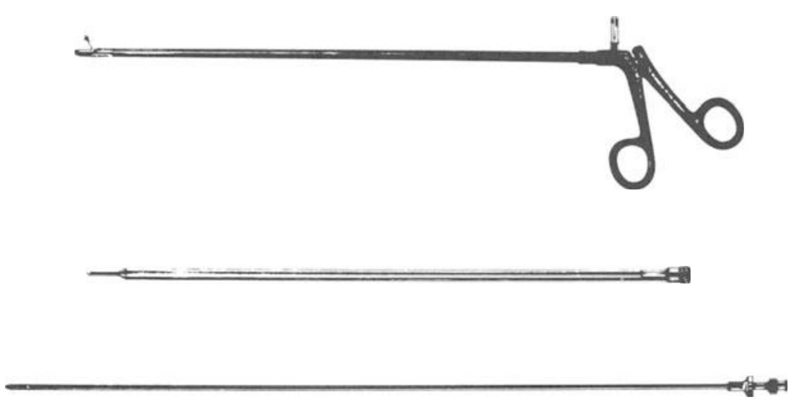


FIGURE 6-3. Instruments for laparoscopic biopsy (top to bottom): forceps with teeth; 5-mm fine needle aspiration tube; 3-mm hook needle.

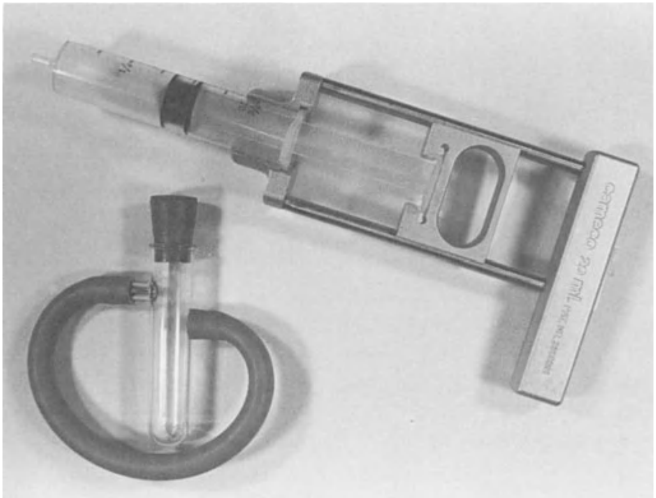


FIGURE 6-4. Systems for collecting ovarian aspirates: syringe and pistol handle, Leuken tube.

Means for hemostatic coagulation: Various energy sources can be used effectively:

1. Unipolar button electrode or alligator forceps
2. Bipolar forceps
3. Endothermal point coagulator or crocodile forceps
4. YAG laser with a round or chisel sapphire tip

The unipolar system is the most effective but also causes the most widespread thermal damage.

Other: A suitable uterine elevator, calibrated probe, hook needle (Fig. 6-3), scissors, loop ligature and applicator, and other instruments may be needed as described in Chapters 2 and 3.

Diagnostic Ovarian Biopsy

The role of laparoscopic ovarian biopsy in the management of primary and secondary amenorrhea, oligomenorrhea, polycystic ovarian disease (PCOD), and infertility with regular menses has been the subject of debate. Yuzpe and Rioux[2] suggested in 1975 that ovarian biopsy was indicated in most infertile patients. Later, Cohen and de Meirelles[3] confirmed a beneficial effect of ovarian biopsy in infertile women, reporting a pregnancy rate of 37% in 477 cases; the rate reached 57% when patients with tubal or male factor were excluded. Other investigators[4–6] have taken a more conservative approach, stating that in view of its inherent risk ovarian biopsy should be reserved for specific indications.

The safety of ovarian biopsy can be improved by holding the ovary securely throughout surgery so as not to lose sight of any bleeding vessels and by taking the biopsy from the ovarian cortex away from the hilum. Alligator-type biopsy forceps are preferred to drill-type biopsy instruments, which may be inadvertently drilled into the vascular medulla or hilum causing profuse bleeding.

To assess the benefit of ovarian biopsy one must consider the diagnostic advantage of histologic examination over visual inspection as well as the possible therapeutic effect of the biopsy.

Primary Amenorrhea

Primary amenorrhea is defined as absence of spontaneous menses in women 16 years of age or older. The diagnosis is based on clinical examination, level of serum gonadotropins, chromosomal analysis, and ovarian biopsy, as shown in Table 6-1. Ovarian biopsy offers the added advantage of determining the karyotype of ovarian tissues. This step is important in patients with mosaicism, as the karyotype of peripheral blood and ovarian tissue cell lines may not be identical. The ratio of normal to abnormal cell lines in each site determines the degree of expression of somatic stigmata and the status of follicular ovarian development.[7]

The presence of a Y chromosome (in a single or mosaic cell line) is an indication for gonadectomy. On the other hand, the finding of ovarian stroma with primordial follicles in association with elevated gonadotropins (Savage syndrome) can offer hope for treatment with large doses of menotropins. Ovarian biopsy may have a therapeutic effect in such cases, as the procedure has been shown to induce ovulation leading to pregnancy in seven of ten patients presenting with the gonadotropin-resistant ovary syndrome.[3]

Secondary Amenorrhea

Secondary amenorrhea may be defined as the absence of spontaneous menses of at least 6 months duration. The role of ovarian biopsy in secondary amenorrhea is less clear. As clinically necessary, laparoscopic inspection may suffice to classify the ovaries according to macroscopic and microscopic appearances when endocrinologic assessment is unsatisfactory; Table 6-2 conveys these two parameters. However, as seen in Table 6-3, Portuondo et al.[11] reported a different correlation. Discrepancies between histologic findings and clinical behavior have also been reported.[12] Ovaries with follicular activity or corpora lutea were noted in patients with menopausal symptoms associated with high serum gonadotropin values. Conversely, ovaries without follicular elements were noted in patients with normal serum gonadotropin.[10] Also, women

TABLE 6-1. Ovarian Biopsy after the Diagnosis of Primary Amenorrhea

Gonadotropins	Karyotype	Gonadal biopsy	Diagnosis
Normal	46XX	Ovarian stroma with follicles	Genital tract anomaly[a] Delayed puberty Other endocrine disorders[b]
Elevated	46XX	Ovarian stroma with follicles	Follicular premature ovarian failure (Savage syndrome)
		Ovarian stroma without follicles	Afollicular premature ovarian failure
		Fibrous tissue	Pure gonadal dysgenesis
	46XY[c]	Testis	Androgen insensitivity syndrome
		Fibrous tissue	Swyer's syndrome
	45X	Fibrous tissue	Turner's syndrome
	47XXX		Triple X syndrome
	45X mosaic	[d]	Gonadal dysgenesis[d]
Decreased	46XX	Ovarian stroma with follicles	Anosmic amenorrhea (female Kallman's syndrome) Isolated gonadotropin deficiency Panhypopituitarism

See refs. 2 and 6–9 for further discussion.

[a] Normal ovaries with rudimentary uterus, uterine aplasia, lower tract atresia.

[b] Hyperprolactinemia, hypothyroidism, congenital adrenogenital syndrome, juvenile-onset diabetes mellitus, Laurence-Moon-Biedl syndrome.

[c] Single or mosaic cell line.

[d] Histology of ovarian biopsy and degree of expression of somatic stigmata depend on percentage of abnormal cell line.

TABLE 6-2. Classification of gross appearance and corresponding histologic description of ovaries

	Gross appearance		Histologic description
1	*Normal:* rugal surface with visible developing follicles or corpus luteum	A	Normal: stroma with developing follicles or corpus luteum
2	*Resting:* smooth surface without follicles or corpus luteum	B	Stroma with resting primordial follicles
		B+	Stroma with modest follicular development
3	*Polycystic:* white, smooth, thick, vascularized capsule with numerous subcapsular cysts	C	Thick tunica, cystic and atretic follicles, thick and hyperplastic theca interna
4	*Atrophic:* wrinkled, irregular surface with deep sulci	D	Stroma with no follicles

Modified from Sykes and Ginsberg.[10]

without follicles on ovarian biopsy samples have conceived.[4]

Some of the discrepancies may be explained on the basis of biopsy size. Because the distribution of ova along the outer layer of the cortex underneath the capsule is patchy,[6,12] a small biopsy specimen taken between the patches may not show follicular activity. To give an accurate estimate of follicular mass, the biopsied ovarian tissue should measure at least 1 cm (in greatest dimension).[12] Other discrepancies most likely indicate a wide spectrum of biologic behavior and response. The therapeutic benefit of ovarian biopsy in patients with Savage syndrome has already been mentioned.

Ovarian biopsy or resection was performed on 16 patients with secondary amenorrhea. Three of these patients had premature ovarian failure at 30, 42, and 32 years of age, respectively, and two had PCOD. One of the patients with PCOD resumed regular menses 1 month after the biopsy. The response to ovarian resection was better than that noted with single ovarian biopsy.

Suspicious Lesions

Small isolated lesions protruding from the surface of the ovary are commonly prolapsed remnants of corpora albicantia and should be biopsied if they look suspicious. Biopsy should be preceded by careful inspection of the pelvis and diaphragm and collection of pelvic washings. The histologic diagnoses of four such lesions were polypoid ovarian remnants, polypoid corpora albicantia, ovarian fibroma, and metastatic carcinoma of an unidentified primary. Diagnostic laparoscopy was performed in the last patient to identify

TABLE 6-3. Comparison between gross appearance and corresponding ovarian histology

	Histologic classification[a]				
Gross appearance[a]	Normal (A)	Resting primordial follicles (B)	Cystic atretic follicles (C)	Stroma with no follicles (D)	All cases
1 (normal)	10			2	12
2 (resting)	52	11		3	66
3 (polycystic)	7		20		27
4 (atrophic)	1	1		7	9

Abridged from Portuondo et al.[11]
[a] As defined in Table 6-2.

the primary site of malignancy in association with metastases to the skull.

Ovarian Biopsy: Technique

A 10-mm laparoscope allows sufficient light for use of the video camera if desired. Working off the video screen offers the advantages of magnification, participation of operating room staff, the surgeon's comfort, and availability of a permanent record that can be shown to the patient or health care providers (see Chap. 11). The disadvantages include loss of depth perception and, in some cases, true color, diminished resolution of the transmitted picture, and the need to develop appropriate hand–eye coordination.

A three-incision technique may be preferred, as described in Chapter 3. One incision is made for the primary open laparoscope cannula (and viewing scope) and two incisions for pelvic organ manipulation. These incisions are positioned in the right and left lower quadrants about 6–8 cm above the inguinal ligament outside the lateral margin of the rectus muscle. All of the second incision trocars and sleeves are 5.5 mm in diameter, unless the CO_2 laser is used, in which case an 8-mm sleeve is required. If 3-mm instruments are needed, a 3-mm reducing sleeve is introduced into the 5.5-mm cannula.

The first step of the procedure is to hold the ovary securely. A three-pronged self-holding forceps may be preferred for holding the ovary at any point away from the hilum. In order to make the grasp more secure, the application is locked by tightening the screw positioned near the handle of the instrument. The ovary is then inspected carefully, exposing all surfaces and borders by rotating the three-pronged forceps. After inspecting the diaphragm and obtaining pelvic washings, any suspicious looking excrescences are biopsied. The 5-mm biopsy forceps are used to obtain a biopsy specimen, thereby creating a small defect in the ovarian capsule and cortex. If it is not successful, a 3-mm hook needle is used to puncture the ovarian capsule (Fig. 6-3). In either case, the counterpressure needed to achieve ovarian penetration is provided by the stabilizing three-pronged forceps (Fig. 6-5). Once the ovarian surface is breeched by the forceps or needle, additional biopsy specimens can be obtained easily. One jaw of the biopsy forceps is positioned into the ovarian defect and the other outside the ovary (Fig. 6-6). The biopsy is then performed. The specimen is usually 3–4 mm thick and 4 mm in length and width when using 5-mm alligator-type biopsy forceps. Several specimens are taken to ensure a representative sample. The operative site is usually irrigated and flushed several times during the procedure to identify bleeding vessels. The biopsy site is coagulated to obtain adequate hemostasis. The ovary that was being held throughout the procedure with the three-pronged forceps is

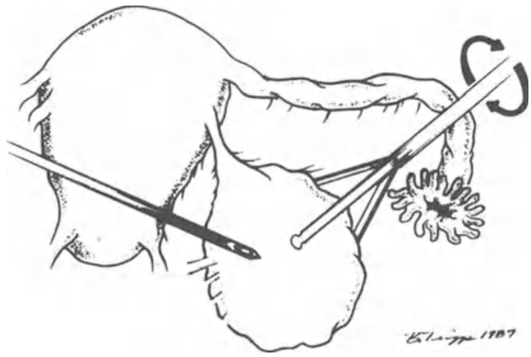


FIGURE 6-5. Ovarian puncture to facilitate biopsy.

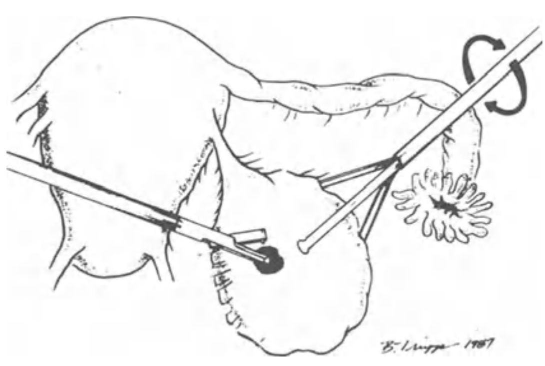


FIGURE 6-6. Ovarian biopsy.

released after achieving satisfactory hemostasis. The pelvis is lavaged until it is clear, removing blood, fluids, and debris from the cul-de-sac (see Chaps. 2 and 3).

Cibils[13] described a useful method for stabilizing the ovary that can be used in association with the three-pronged forceps. The ovary is grasped and pulled gently upward, and the uterus maneuvered into the sacral concavity using the uterine manipulator. The ovary is then placed on top of the uterine fundus, which acts as a supporting platform. Yuzpe and Rioux[2] used the uterine manipulator to sweep the lateral pelvic wall so as to place the ovary on the uterine fundus.

The Palmer drill forceps or a modified version can be used to obtain an ovarian biopsy specimen. The ovary is held with the prongs of the forceps at a selected site on the antimesenteric border. The sharp drill is turned into the ovarian substance to the desired depth. The angle of drilling is changed so as to completely excise the base of the biopsy. The forceps are then withdrawn and reapplied for additional specimens, as needed. Although this method obtains a generous sample, it is not recommended for two reasons:

1. Cutting a deep biopsy increases the risk of bleeding from the ovarian medulla, as it may be difficult to control the depth of tissue penetration.
2. Withdrawing the forceps before complete separation of the base of the biopsy from the remaining ovary causes unpredictable tears and possibly associated bleeding.

Complications

Possible complications include hemorrhage and injury to adjacent structures. Intraoperative hemorrhage has been reported by several investigators,[2–6] and may result from deep biopsies and unpredictable tears. Postoperative bleeding is a function of inadequate hemostasis. Bleeding vessels that are not coagulated or are insufficiently coagulated become covered with a thin coagulum that subsequently separates causing postoperative bleeding. Frequent irrigation of the biopsy site to identify bleeding vessels is critical for adequate hemostasis. Inadequate hemostasis is also a contributing factor in the formation of adhesions.

Mechanical, electrical, or laser-induced damage to surrounding structures, most notably bowel, fallopian tube, and ureter,[4] may result from inappropriate use of instruments. The ovary should be held away from other structures with the three-pronged forceps during coagulation using the preferred energy source to minimize the possibility of such damage.

Summary

Simple ovarian biopsy is indicated for patients with primary amenorrhea or small suspicious ovarian excrescences. Ovarian biopsy is also recommended for selected cases of secondary amenorrhea, such as patients in whom the possibility of Savage syndrome exists.

Therapeutic Ovarian Resection

The Stein-Leventhal syndrome, now commonly referred to as polycystic ovarian disease or chronic anovulatory syndrome[14] is one of the most enigmatic entities in gynecology. Its etiology remains unknown, its pathophysiologic mechanisms uncertain, and treatment modalities debatable. The syndrome is characterized by polycystic ovaries fundamentally associated with anovulation, hirsutism, and infertility. Ovarian wedge resection was recommended by Stein and Leventhal[15] in 1935 and remained the accepted method of treatment until the 1960s when it was gradually replaced with the administration of clomiphene citrate with or without human chorionic gonadotropin (hCG). Several reports[16–18] appeared during the mid-1970s linking the operation to postoperative pelvic adhesions and mechanical infertility. Ovarian wedge resection soon fell into disfavor, for although the ovulation induction effect of the procedure was not questioned the potential for causing mechanical infertility secondary to tuboovarian adhesions was considered unacceptable. The induction of ovulation with the use of pharmacologic therapy in patients with PCOD was soon noted to present occasional difficulty.

There continued to be a need to explore other types of ovarian surgery particularly for patients who were resistant to medical treatment. Using the laparoscopic approach, Campo and colleagues[19] reported on ovarian resection by means of multiple biopsy in 1983. Gjonnaess[20] described ovarian cautery in 1984, and most recently Daniell[21] discussed ovarian laser vaporization, all with good results. The application of microsurgical[22] and microlaser[23] techniques to the procedure of ovarian wedge resection has been suggested. Interestingly, Hjortrup and colleagues[24] continued to rely on classic ovarian wedge resection as the first line of treatment for patients with PCOD and reported good results with long-term follow-up.

Functional and Histopathologic Changes in PCOD

Polycystic ovarian disease is associated with altered amplitude and frequency of release of the gonadotropin luteinizing hormone (LH), which leads to defective follicular development as well as to a state of androgen excess. This situation in turn leads to abnormal release of gonadotropins; thus a vicious cycle develops perpetuating the problem. The increased tonic release of LH drives the target theca cells surrounding the ovarian follicles to grow and secrete androgens, which are partly stored in the follicles. It leads to excessive androgen levels in the serum and follicular fluid.[25,26] Nonsteroidal substances that inhibit ovulation, e.g., inhibin, also accumulate in the follicular fluid of patients with PCOD.[25,27] Proportionately reduced levels of follicle-stimulating hormone (FSH) do not support normal development of the granulosa cells of the follicle or the secretion of normal amounts of estradiol (E2) from these cells. Given this pattern of gonadotropin secretions, the ovarian follicles usually do not grow beyond 8 mm in diameter and tend to persist. Ovulation is inhibited, and the patient presents with hirsutism and other manifestations of androgen excess. The role of adrenal androgens in PCOD is debatable.[25,28]

In order to appreciate technical elements of laparoscopic ovarian resection, it is necessary to summarize the histopathology of PCOD. The ovaries are usually enlarged two to four times normal, although occasionally they are of normal size. Longitudinal section of the ovary reveals a line of thin walled cysts 4–8 mm in diameter immediately underneath a uniformly thickened capsule (approximately 1 mm in thickness). The follicular lining of each cyst consists of normal or atrophic granulosa cells. The theca interna layer surrounding the granulosa is almost always hypertrophied. The excessive androgen production in PCOD derives from these cortical tissues (theca interna) with only a small contribution from the medullary stromal cells. However, the ovarian stroma occasionally becomes hyperplastic with numerous nests of luteinized cells. These cell nests are responsible for marked androgen excess. Patients with this condition, which is referred to as "hyperthecosis," are usually virilized. This type of stromal hyperplasia is considered one extreme end of the spectrum of PCOD.[25]

Effect of Ovarian Surgery

There is general agreement that ovarian surgery induces ovulation by removing intraovarian steroidal and nonsteroidal substances that inhibit ovulation.[29] Thus the ovarian response to gonadotropins is normalized, permitting ovulation to take place. It is accomplished by any method that destroys, removes, or drains[26] a number of stunted follicles and surrounding cortical thecal cells sufficient to trigger ovulation. In mild cases a single ovarian biopsy or a few cautery or laser ablation points suffice. However, in more advanced disturbances more

TABLE 6-4. Ovulation after ovarian electrocautery correlated with number of electrocautery points (both ovaries)

No. of points	No. of patients	Ovulation induced (% of patients)
<6	6	67
6–10	26	92
>10	30	97

From Gjonnaess H: Polycystic ovarian syndrome treated by ovarian electrocautery through the laparoscope. Fertil Steril 41:20, 1984. Abridged with permission of the publisher, The American Fertility Society.

extensive drainage of follicles coupled with destruction or removal of cortical tissues is required. Gjonnaess[20] found that response to treatment was related to the number of electrocauterized points on the ovaries (Table 6-4). Smaller ovarian resections may be associated with less satisfactory results. It is interesting to note that the size of the removed or destroyed cortex is related to the duration of the response: the larger the segment removed the greater the interval to recurrence of amenorrhea or oligomenorrhea.

Clinical Responses to Ovarian Surgery

The response to ovarian surgery in patients with PCOD in studies using various methods is shown in Table 6-5. More specific details were given in some of the studies (Tables 6-6 and 6-7). The clinical response of these patients supports the theory that ovarian surgery removes intraovarian inhibitors to ovulation. Ovulation occurred as early as 15 days after classic wedge resection[31] and

TABLE 6-5. Response to ovarian surgery in patients with polycystic ovarian disease

Study	Method	Ovulation induction (response/ total patients)		Corrected fertility rate (conceptions/ total patients)	
Laparotomy					
Adashi et al.[30]	Classic wedge resection—unspecified	82/90	(91%)	43/90	(48%)
Adashi et al.[30]	Medical treatment (no surgery)	44/61	(72%)	16/61	(26%)
Lunde[31]	Classic wedge resection—ovary reduced to normal size	72/90	(80%)	58/92	(63%)
Hjortrup et al.[24]	Classic wedge resection—ovary reduced to normal size	26/29	(90%)	10/13	(77%)
Laparoscopy					
Campo et al.[19]	Ovarian resection by multiple biopsy; average aggregate size 15 × 10 × 5 mm	—/12	(45%)[a]	5/12	(41%)
Gjonnaess[20]	Ovarian electrocautery, total of 5–16 points each 3–5 mm in diameter	57/62	(92%)	28/48[b]	(58%)
Greenblatt et al.[32]	Ovarian electrocautery, total of 16–20 points each 3–4 mm in diameter	5/6	(83%)	4/6	(66%)
Daniell[21]	Laser vaporization, multiple points each 3–5 mm in diameter	85/85	(100%)	48/85	(56%)
Hasson[c]	Ovarian resection by multiple biopsy, average aggregate size 60 × 5 × 5 mm	29/29	(100%)	11/14[b]	(79%)

[a] Percent of cycles, not patients.
[b] Without regard to other infertility factors.
[c] 1988, unpublished data.

TABLE 6-6. Spontaneous ovulation following ovarian biopsy

Condition	Laparoscopy			Laparotomy	
	Resection[a]	Electrocautery[20]	Laser[21]	Wedge resection[31]	Wedge resection[24]
Failed preop. medical therapy	16/16	9/9	85/85	72/90	0
No preop. medical therapy	13/13	48/53	0	0	26/29
Total	29/29	57/62	85/85	72/90	26/29
	(100%)	(92%)	(100%)	(80%)	(90%)

Expressed as response/total number of patients.
[a] Hasson, unpublished data.

between 1 and 2 weeks in most patients responding to electrocautery of the ovarian capsule.[29] Menses ensued 24–33 days after point electrocoagulation in five of six patients.[32] Campo and co-workers[19] reported that ovulation occurred 16–29 days after laparoscopic resection (average 23 days), and menses took place at 30–43 days (average 37 days). Most patients responded with regular menses within 3 months in the Gjonnaess[20] ovarian electrocautery study, in agreement with this author's experience (unpublished data).

The onset, degree, and duration of response depend on the adequacy of surgery, the extent of disease, and the continuation or recurrence of unknown causative factors. The usual approach in the PCOD–infertility patient is to administer clomiphene citrate at a dose of 150–250 mg/day for 5 days after menses. A regimen of human menopausal gonadotropin (pure FSH is preferred) with hCG is started if clomiphene citrate fails. Lack of adequate response, i.e., no ovulation, is an indication for pelviscopic ovarian resection.

Although it is possible to induce ovulation in patients with PCOD with relatively minor degrees of ovarian trauma, e.g., simple biopsy or a few electrocoagulation points, the duration of the beneficial response is probably related to the size of the resected or destroyed ovarian cortex. Authors using less extensive methods have noted that the effect was transient: Daniell[21] found that most patients in his study reverted to anovulatory cycles within a year, and Gjonnaess[20] remarked that the ovulatory response was of a limited duration. On the other hand, Hjortrup et al.[24] removed up to 75% of the ovarian mass bilaterally so as to reduce ovarian size to normal. They reported a negligible recurrence rate over a mean follow-up time of 5.7 years (range 2.3–9.5 years). Lunde,[31] who also used wedge resection to normalize the size of polycystic ovaries, indi-

TABLE 6-7. Pregnancy following ovarian biopsy

Condition	Laparoscopy			Laparotomy	
	Resection[a]	Electrocautery[20]	Laser[21]	Wedge resection[31]	Wedge resection[24]
Failed preop. medical therapy	8/11	—	48/85	58/92	0
No preop. medical therapy	3/3	—	0	0	10/13
Total	11/14[b]	28/48[b]	48/85	58/92	10/13
	(79%)	(58%)	(56%)	(63%)	(77%)

Expressed as response/total number of patients.
[a] Hasson, unpublished data.
[b] Includes patients with other infertility factors.

cated that one-third of treated patients established regular menses for more than 6 years. Figure 6-7 illustrates the intermediate position of laparoscopic resection between laparoscopic point ablation (by laser or cautery) and the classic wedge resection that reduces the size of a polycystic ovary to normal. Less favorable results were obtained by Campo et al.,[19] who reported on the effect of laparoscopic (celioscopic) ovarian resection in patients with polycystic ovaries. The aggregate size of the resected fragments in that study was only 1.5 × 1.0 × 0.5 cm (Table 6-5).

Several investigators[24,31] have shown that in patients with PCOD treated with ovarian surgery the best predictor of subsequent conception was the occurrence of regular menses. The continuation or recurrence of oligoovulation after ovarian surgery is an indication of inadequate response to surgery. An organized second-look procedure is not indicated for PCOD patients treated with laparoscopic resection, particularly if the treatment is successful. It is difficult, therefore, to evaluate the occurrence of postoperative adhesions in many treated patients. However, laparoscopy or cesarean section performed over the years on nine treated patients in a series evaluated by Hasson (unpublished data) failed to reveal pelvic adhesions 9–98 months after the initial laparoscopic ovarian resection procedure. Daniell[21] has had a similar experience. Gjonnaess[20] found periovarian adhesions following electrocautery in one patient who failed to conceive and no adhesions at subsequent cesarean section in five other patients. These experiences with laparoscopic technique are in sharp contrast to those dealing with open wedge resection. Adhesions were found in 7 of 7,[30] 59 of 59,[16] and 11 of 12[34] patients who were investigated by laparoscopy or laparotomy.

Laparoscopic Ovarian Resection: Technique

The techniques used for diagnostic ovarian biopsy and therapeutic resection are similar, as resection is essentially multiple ovarian biopsies. The differences relate to the number (and aggregate size) of the biopsies. Additionally, an attempt is made to rupture, drain, or destroy many of the small ovarian follicles characteristic of the disease. The size of the resected tissues depends on the size of the polycystic ovary: the larger the ovary, the greater the number of biopsies necessary. Using the 5-mm biopsy forceps, each biopsy ordinarily is 3–4 mm thick and 4–5 mm in length and width. Five to twelve biopsy specimens are taken from each ovary, depending on ovarian size. Once the first specimen is cut, one can direct the jaws of the forceps to excise additional specimens so as to create a shallow trough, a stellar form, or a combination thereof (Fig. 6-8). The defects are made slightly deeper by scooping

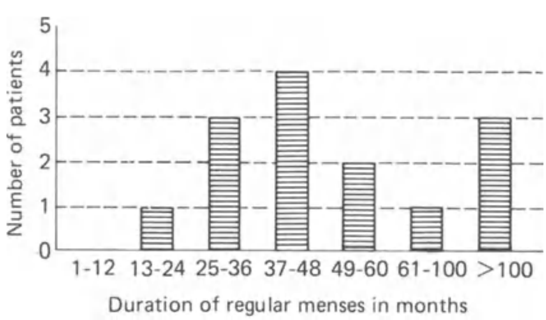


FIGURE 6-7. Duration of spontaneous regular menses in 14 treated patients followed for more than 3 years.

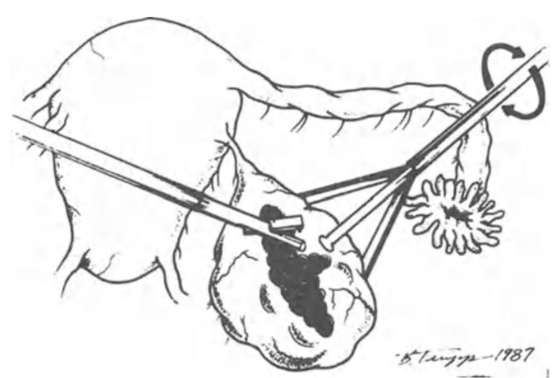


FIGURE 6-8. Ovarian resection.

out additional portions of the cortical subcapsular follicular tissue using the biopsy forceps. The needle electrode or chisel sapphire tip of the YAG laser is then used to puncture and drain cystic follicles of PCOD exposed within the site of resection. Appreciation of surgical anatomy indicates that one need not get any deeper than 8 mm during this process. The edge and bed of the resection site are then coagulated using the preferred energy source. Adequate hemostasis is essential, as it prevents the possibility of postoperative bleeding and mitigates against the formation of adhesions. One may choose to coagulate the bed of the trough more extensively instead of or in addition to scooping out follicular tissue and draining the follicles. The extent of follicular destruction would be tailored to the size of the ovary and extent of the disease.

Complications

The complications of ovarian resection are similar to those of ovarian biopsy. The more extensive nature of ovarian resection increases the potential for complications and the need for using a meticulous technique. Occasionally, there is brisk bleeding from biopsy sites, but it can be controlled uneventfully with careful irrigation, identification of the bleeding points, and hemostatic coagulation.

Summary

Laparoscopic ovarian resection is indicated for women with PCOD who are resistant to clomiphene citrate therapy. Resection appears to improve the hormonal milieu by removing cortical segments of the ovary that may contain substances inhibiting ovulation. Frequently, ovulation is induced promptly, and pregnancy follows in patients with no other infertility factors. Lack of response to surgical intervention indicates that the amount of resected tissue was not sufficient for normalizing the ovarian disturbance. Repeated laparoscopic ovarian resection should be considered if there is no response within a year. Postoperative adhesions are not expected to occur with the use of gentle tissue mainpulation and achievement of adequate hemostasis.

Ovarian Cyst Aspiration

Aspiration of ovarian or paraovarian cysts has no therapeutic value. Kleppinger[35] reported that whereas two of six functional cysts aspirated at laparoscopy recurred within 6–12 months there were no recurrences among 52 patients with cysts treated with fenestration. Burmucic et al.[36] noted a recurrence rate of 11% for aspirated ovarian cysts and a higher rate for paraovarian cysts. Larsen and colleagues[37] commented that ovarian cyst aspiration was unsatisfactory, as it did not provide for histologic examination or permanent drainage of the cyst. Others have made similar observations.[38]

Fine needle aspiration (FNA) is a safe and useful diagnostic modality commonly used to establish the nature of cystic masses in many organs and under various clinical conditions. However, despite its popularity, FNA has enjoyed a limited application for diagnosis of ovarian cysts and masses, probably because of a general lack of clinical awareness, the complexity of cytologic interpretations due to the wide diversity of normal and pathologic cells that may be aspirated from the ovary, and the need for skillful manipulation of the ovary so as to secure an adequate representative sample.[39,40] The technique has its limitations in the best of hands: It cannot differentiate between benign and borderline tumors or between various benign cysts lined by a single layer of cuboidal cells, and it may miss a localized ovarian malignancy.

Pelviscopic FNA is an integral prerequisite step of ovarian cyst fenestration. It is also useful for evaluating solid or cystic ovarian masses and for postoperative follow-up of patients with ovarian cancer. The differential diagnosis between functional and neoplastic cysts can be supplemented by ultrasound and by measuring estradiol in the aspirated cyst fluid by radioimmunoassay (RIA). Estradiol values over 500 pg/ml are suggestive of a functional cyst.[41,42] Criteria developed for differentiating benign from malignant ovarian cysts by ultrasound are shown in Table 6-8. Benign lesions are usually unilocular or multilocular with thin septa and no solid components. Malignant lesions tend to be multiloculated with thin septa and solid components or with thick septa regardless of the presence or absence of nodules.[43]

The use of transvaginal or transrectal FNA or ultrasound-guided puncture of ovarian cysts has the disadvantages of laparoscopic puncture—including a high recurrence rate and diagnostic uncertainty—without the advantages of direct visual assessment and control offered by the laparoscope. De Crespigny et al.[44] noted that it was difficult to aspirate the thick fluid of endometriomas managed with ultrasound-guided puncture and reported a recurrence rate of 70%. Diernaes and colleagues[45] missed five of seven malignant cysts and identified one benign cyst as malignant using ultrasound-guided transabdominal puncture combined with cytologic examination of cystic fluid. The use of transvaginal or transrectal FNA of ovarian cysts was also disappointing as reported in two other studies.[42,46] In one of the studies,[42] severe pelvic infection followed aspiration of ovarian cysts in 3 of 223 patients.

TABLE 6-8. Ultrasound characteristics of ovarian cysts

	Incidence (%)		
Characteristic	Benign	Malignant	Total
Size of cyst			
<5 cm	23	0	23
>5 cm			
Unilocular	17(89)	2(11)	19
Multilocular	11(41)	16(59)	27
Multilocular cysts			
Thin septa <3 mm			
Without nodules	8(89)	1(11)	9
With nodules	2(20)	8(80)	10
Thick septa >3 mm			
Without nodules	0	0	0
With nodules	1(12)	7(88)	8

Modified from Meire et al,[43] with permission of Blackwell Scientific Publications Limited.

Ovarian Fine Needle Aspiration: Technique

The ovary is inspected carefully using the three-pronged forceps, and target area(s) are identified. The ovary is held securely with the three-pronged forceps or otherwise stabilized. The 5-mm FNA instrument shown in Figure 6-3 is fitted into the pistol syringe shown in Figure 6-4. The FNA instrument is directed into the abdomen through a strategically located ancillary incision, and the needle is inserted into the target area (Fig. 6-9). Aspiration is performed by creating continuous negative pressure in the attached syringe and moving the needle forward and backward in different directions with short and then longer strokes. The negative pressure within the syringe is released before the needle is withdrawn from the ovary.[39,47] Alternatively, the FNA instrument is attached to a Leuken tube (Fig. 6-4), which is connected to central wall suction. FNA is then performed, as discussed previously. In either case, following aspiration the minute puncture site is sealed by coagulation using the preferred energy source so as to prevent spillage of cyst contents into the abdomen. The FNA instrument is with-

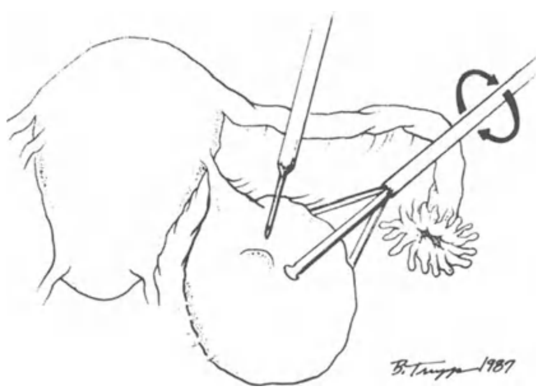


FIGURE 6-9. Fine needle aspiration of ovarian cyst.

drawn from the abdomen, and the specimen is transmitted to the laboratory for cytologic processing. FNA of solid masses is best accomplished with the pistol syringe. Following aspiration, the syringe is detached and filled with air. The sample is expelled onto glass slides by pushing air into the barrel of the thin needle. The material is spread over the slides, which are immediately immersed in 95% ethanol or sprayed with a fixative.[39,30]

Ovarian Cyst Fenestration

Cystic ovarian enlargements that occur during the reproductive years are commonly due to regressive functional changes. Ovarian cystomas appear to originate from surface epithelium that becomes trapped underneath the surface during the process of ovulation, forming epithelial inclusion cysts. The surface epithelial cells undergo spontaneous and induced transformation in their new location. Mutants accumulate inside the ovary and do not desquamate as they normally do on the ovarian surface. Some of the transformations of the enmeshed cells may lead to benign and malignant neoplasia.[48] The protective effect of cell desquamation was described by Cairns,[49] who suggested that in rapidly proliferating tissues the risk of malignant transformation from spontaneous mutations during DNA replication, or from mutations induced by carcinogenic agents, is counteracted by continuous desquamation.

Management of ovarian cysts by laparoscopy offers distinct advantages over management by laparotomy (see Chap. 23).

1. Shorter time for recovery and return to work, and reduced morbidity and hospital stay
2. Minimal occurrence of postoperative adhesions and ensuing mechanical infertility
3. Maximal preservation of the ovary
4. Improved cosmetic result

The technique of fenestration of ovarian cysts is similar to that of marsupialization of Bartholin duct cysts. In both instances the cysts heal well and rarely recur. With ovarian cyst fenestration, removal or ablation of the cyst lining, particularly if endometriotic, is important for the prevention of recurrence. In a series of 22 endometriotic cysts managed laparoscopically, 13 cases were treated with fenestration combined with ablation or removal of the cyst lining, and nine were treated with fenestration (and biopsy) alone (unpublished data). The results shown in Table 6-9 clearly indicate that in order to obtain a satisfactory response the lining of the endometrioma must be removed or ablated. The same is probably true for simple ovarian cystomas. Although the window in the cyst would offer the cells of the lining an opportunity to desquamate, eventually the opening closes and mutating cells may reaccumulate.

Gynecologic oncologists are generally adamant in their opposition to ovarian cyst as-

TABLE 6-9. Pelviscopic surgical treatment of ovarian endometriomas with and without removal or coagulation of the cyst lining

Treatment	Total No. of patients	Pregnancy occurred	Endometrioma recurred
Fenestration with removal or ablation of cyst wall	13	5/5	1/13
Fenestration without removal or ablation of cyst wall	9	2/5	8/9

From Hasson, unpublished data.

piration or fenestration. Their resistance is based on three premises.

1. Functional cysts (even if associated with pain) require no active treatment and recede spontaneously.
2. Cysts larger than 5 cm may represent endometriosis or a neoplasm and require laparotomy.
3. The risk of spilling a malignancy and converting a stage IA to a higher stage is unwarranted, as it leads to a worse prognosis.

Although many functional cysts regress spontaneously or under the influence of oral contraceptives (OCs)[50] in 6–8 weeks, many do not. Reports indicate that the protective effect of OCs on the development of functional cysts may be limited to monophasic combination pills.[51,52] The patients usually present with pelvic pain, dyspareunia, or menometrorrhagia, and a few present with a pelvic mass. A therapeutic trial with OCs is undertaken to treat functional cysts unless the patient presents with acute pelvic pain or chronic menometrorrhagia or she has been followed for 2 months or longer—with or without a trial of OCs. Patients who are over 40 should not be treated with hormonal contraception.

A suggested protocol for laparoscopic management of ovarian cysts is presented in Figure 6-10. This protocol should not be contingent on size per se (with a reasonable maximum of 8–10 cm as a limiting factor). In one case, for example, a 7- to 8-cm cyst in a 77-year-old woman treated with laparoscopic fenestration had all the characteristics of a benign retention cyst. Furthermore, laparoscopic technique is uniquely suited to the management of large endometriomas, as previously discussed.

Age is also not a limiting factor, although more strict criteria of selection are used for

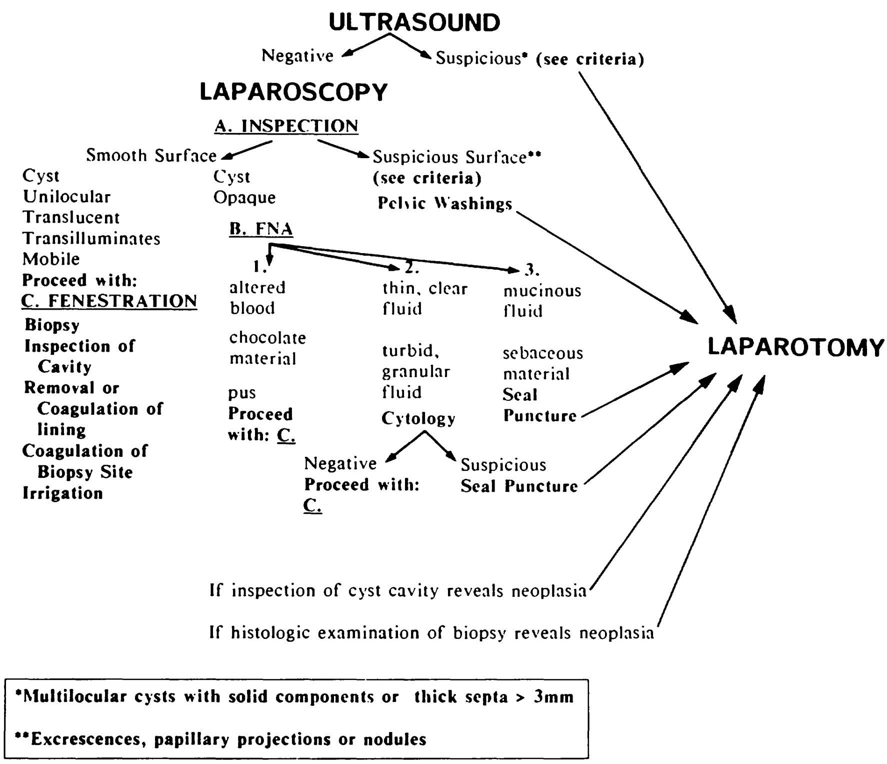


FIGURE 6-10. Ovarian cyst fenestration protocol.

patients over 40 years of age. Westhoff and Beral[53] found that ovarian cysts diagnosed in women 55 years or older were mostly benign neoplasms (or retention cysts). Interestingly, the age-specific rate of ovarian cysts in this British study[53] is similar to that seen by the author (Fig. 6-11).

Experience with FNA in other organs of the body has not shown an increased risk of spreading cancer.[42,43] The use of FNA for the assessment of ovarian masses and cysts also was not associated with an increased risk of disseminating cancer.[42,47] Spillage that occurs with laparoscopic fine puncture is different from that following gross rupture of a malignant ovarian cyst during open surgery. Any leakage from the laparoscopic thin needle puncture can be further minimized by coagulating and sealing the puncture site. Under such circumstances, the small number of malignant cells that may escape following FNA of ovarian cancer would most likely be under the threshold required for a seeding. Munnell,[54] reporting on 235 cases of primary ovarian carcinoma, showed that a spill at the time of surgery for early ovarian cancer did not compromise the prognosis. On the other hand, Webb and associates[55] reviewed 271 patient charts and found a reduced 5-year survival rate when malignant cysts ruptured at surgery. They also noted that cystic lesions that ruptured during surgery were more likely to be of higher histologic grade and to show other characteristics indicating aggressive behavior, e.g., adherence to surrounding structures and extracystic excrescences. Thus it is probable that the worse prognosis associated with cystic rupture is not due to the rupture but to the nature of the lesion. More recently, Dembo and colleagues[56] analyzed the records of 639 patients with stage I ovarian cancer in Norway and concluded that cyst rupture did not influence the risk of relapse, merit identification by a separate subcategory, or warrant more aggressive treatment. Tumor implantation after laparoscopic biopsy of two ovarian tumors has been reported.[57] However, both patients had aggressive neoplasms with extracystic excrescences, and neither was evaluated with FNA.

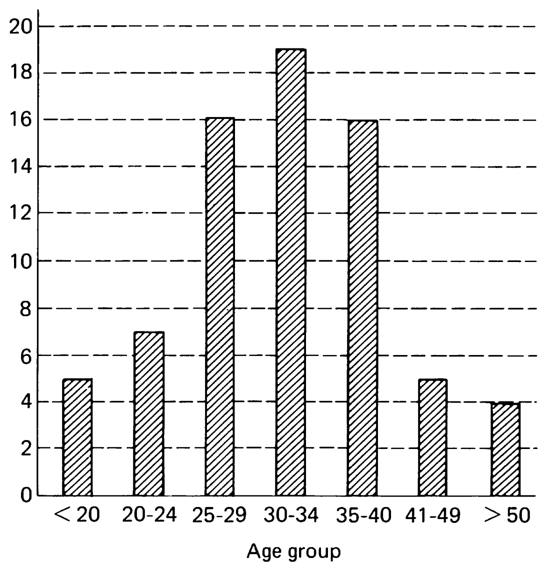


FIGURE 6-11. Number of benign ovarian cysts in the age groups in the study.

Clinical Experience

The results of three studies dealing with ovarian cyst fenestration are shown in Tables 6-10, 6-11, and 6-12. Excellent results can be anticipated with proper selection of patients. Most, but not all, patients with functional cysts can be spared a laparotomy. As noted in Table 6-13, simple, follicular,

TABLE 6-10. Pelviscopic management of ovarian cysts: inspection followed by laparotomy

Diagnosis	Larsen et al.[37] (n = 47)	Hasson[a] (n = 77)
Simple or follicle cyst	3	2
Corpus luteal cyst	1	2
Endometrioma	11	3
Dermoid cyst	9	2
Mucinous cystadenoma	3	1
Paraovarian cyst	1	—
Papillary serous cystadenoma, borderline tumor	—	1
Total	28	11

[a] Unpublished data.

TABLE 6-11. Pelviscopic management of ovarian cysts: aspiration followed by laparotomy

Diagnosis	Kleppinger[35] (n = 64)	Hasson[a] (n = 77)
Dermoid cyst	2	2
Serous cystadenoma	2	—
Mucinous cystadenoma, borderline tumor	—	1
Total	4	3

[a] Unpublished data.

and endometrioid cysts are most common in the 30- to 34-year-old age group, luteal cysts are most common among women 35–40 years old, and paraovarian cysts are seen most often in the 20- to 24-year old group.

The combined experiences of Hasson (unpublished data), Kleppinger,[35] and Larsen et al.[37] indicate a low recurrence rate of functional or simple ovarian cysts treated with laparoscopic fenestration. The significance of removing the cyst lining, especially for endometriotic cysts, has been previously stressed.

Ovarian Cyst Fenestration: Technique

Laparoscopic fenestration of ovarian cysts must follow strict guidelines to ensure patient safety. Ultrasonography is used to screen ovarian cysts that reveal suspicious features (Fig. 6-10). Careful inspection of the ovary and other intraabdominal organs is the first step of the laparoscopic approach. The ovary is held securely from its antimesenteric border with the three-pronged forceps and rotated so as to explore all of its surfaces. If suspicious excrescences are de-

TABLE 6-12. Pelviscopic management of ovarian cysts using fenestration

Diagnosis	Kleppinger[35] (n = 64)	Larsen et al.[37] (n = 47)	Hasson[a] (n = 77)
Simple or follicle cyst	20	11	22
Luteal cyst	11	1	15
Paraovarian cyst	8	1	6
Endometrioma	8	—	18
Serous cyst	6	—	2
Dermoid cyst	—	1[b]	—
Mucinous cystadenoma	—	1[c]	—
Other benign	1[d]	4[e]	—
Total	54	19	63

[a] Unpublished data.
[b] Patient hospitalized for pain for 10 days.
[c] Removed by laparotomy later.
[d] Nephrogenic cyst.
[e] Unclassified, with normal cytology.

TABLE 6-13. Evaluation according to type of cyst by age group

Type of cyst	No. of cysts, by age group >50	41–44	35–40	30–34	25–29	20–24	<20	Total
Simple follicle	4	3	5	7	4	2	1	26
Luteal	0	1	8	3	3	1	1	17
Endometrioid	0	0	3	9	8	1	0	21
Paraovarian	0	1	0	0	1	3	1	6
Total	4	5	16	19	16	7	3	70

From Hasson, unpublished data.

tected, the patient is managed by laparotomy. However, it is easier to inspect the diaphragm and to obtain brushings and washings from target areas using a laparoscopic technique. Observing the findings magnified on a video monitor assists the physician in making the diagnosis while holding the interest of the entire operative team. Other steps in the procedure are shown in Figure 6-10. It is important to inspect the cyst cavity following fenestration for the presence of nodules or papillae. Histologic confirmation is obtained by cutting a representative biopsy specimen from each patient.

Complications

No complications were noted in the Hasson study or the Kleppinger study.[35] Larsen et al[37] reported that fenestration performed on a patient with a dermoid cyst was associated with postoperative abdominal tenderness and rigidity that subsided spontaneously. An organized second look is not mandated except for patients with endometriosis. Subsequent surgical procedures performed on patients who have undergone previous cyst fenestration show that the fenestrated cysts had healed without noticeable scarring or adhesions (Hasson, unpublished data).

Possible complications include those associated with ovarian biopsy as well as the potential for spilling ovarian cancer in the pelvic cavity.

Summary

The laparoscopic technique of ovarian cyst fenestration combined with removal or biopsy and ablation of the cyst wall and histologic examination represents the optimal method of managing nonneoplastic symptomatic ovarian cysts, including follicular, luteal, serous, simple, germinal inclusion, suppurative, and endometriotic cysts. Hydatid cysts of Morgagni can be easily excised when clinically indicated. Halban's syndrome, which is defined as persistent corpus luteum, can be managed with fenestration when necessary. Concern about the potential for spread of cancer is understandable given the intraabdominal position of the ovary. This risk is reduced to a minimum with proper selection of patients and careful technique. The potential benefits of this method, including the prevention of postoperative adhesions and mechanical infertility, as well as the reduction of hospital stay and patient morbidity and disability, outweighs the potential risk of converting ovarian cancer from FIGO stage IAi to IAii. Patients exposed to this risk may in fact benefit from the procedure, as the benign appearance of the cyst may have caused treatment delay. Furthermore, studies indicate that the prognosis is not different for patients whose cysts ruptured or did not rupture during surgery for ovarian cancer.[54]

Ovarian Cystectomy

Following fenestration, nonneoplastic ovarian cysts can be removed by stripping the lining of the cyst from the remaining ovary using two instruments that provide traction and countertraction (Fig. 6-12). The procedure is not difficult but requires a certain amount of patience and expertise. This cystectomy technique can be utilized safely for simple cysts and endometriomas. It is an appropriate alternative to ablation of the cyst lining, as discussed previously.

FIGURE 6-12. Ovarian cystectomy.

Oophorectomy

The ovary can be removed by laparoscopic technique rather than by laparotomy for management of conditions that serve as indications for oophorectomy.

1. Primary or metastatic breast carcinoma with positive estrogen receptors
2. Postmenopausal palpable ovary
3. Ovarian endometrioma, dermoid cyst, or other benign ovarian lesions when the ovary need not be preserved
4. As part of salpingo-oophorectomy indicated for benign disease

The intact ovary can be removed through a vaginal colpotomy incision or an umbilical or pubic hairline incision.[58] If open laparoscopy is used, the primary incision can be easily extended to accommodate the size of the extirpated ovary. However, when the benign nature is ensured, the ovary can be morcellated and withdrawn in small pieces using suitable instrumentation[59,60] (see Chap. 2 and 3).

Laparoscopic Oophorectomy: Techniques

Semm and Mettler[60] described a loop ligation method that involves setting down, over the ovarian pedicle, three Roeder loop ligatures, cutting the pedicle distal to all three ligatures, and then coagulating the stump. This procedure is described in Chapter 2.

Reich[58] has reported a bipolar coagulation method whereby the ovary is held securely with a suitable grasping forceps. The infundibulopelvic and uteroovarian ligaments are coagulated and divided individually. Any adhesions are similarly treated so as to free the ovary from its attachments. The ovary is then removed intact or piecemeal, as appropriate.

Hemostatic Coagulation

Hemostatic coagulation of the ovary, essentially for ruptured corpus luteum cysts, is a simple operation that can save many patients from an unnecessary laparotomy. The patient usually presents with acute pelvic pain with or without signs of an acute abdomen. Laparoscopy reveals a hemoperitoneum that may be extensive. The pelvic cavity should be lavaged with copious amounts of a suitable irrigant to identify the source of bleeding, which may be one or two bleeding vessels in the wall of a hemorrhagic ruptured cyst. Using gentle point irrigation, the vessels are localized and coagulated. The procedure is considered complete once hemostasis is achieved.

Other Ovarian Procedures

Other procedures include ablation of endometriotic ovarian implants, release of periovarian adhesions, excision of paraovarian cysts, and oocyte recovery. These procedures are discussed in other chapters.

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7
Pelvic Inflammatory Disease: Pathophysiology and Medical Management

DAVID CHARLES and BRYAN LARSEN

The problems presented by acute pelvic inflammatory disease (PID) are well known to physicians, who usually see the disease from one of two vantage points. PID may first be seen as a medical problem, as it is an infectious process originating in the lower genital tract that subsequently ascends to the upper tract and causes symptoms of abdominal pain. The structures involved cannot be visualized, only palpated, and the precise site of infection cannot be cultured. The goal of the clinician becomes one of selecting an appropriate course of therapy to prevent the disease from becoming a chronic or surgical problem.

The second perspective, in contrast, emphasizes aspects of the disease that cause it to be considered a surgical problem. Surgery is considered when the tuboovarian abscess supervenes. Furthermore, the long-term consequence of infertility in inadequately treated cases may lead to such procedures as hysteroscopy or laparoscopy. Ectopic pregnancy secondary to the damage caused by previous episodes of PID also makes the patient a candidate for surgery. If PID is seen as a surgical problem from the beginning, the physician may more readily consider surgical approaches to the condition.

Laparoscopy represents a surgical procedure that in some respects bridges the gap between the two views cited above. Laparoscopy, however, is not warranted in all cases of PID. In this chapter the nature of the acute disease is emphasized and the medical approach described, followed by discussion of the role of laparoscopy in treating PID. Chapter 8 presents a primarily surgical approach to treating PID. Unless otherwise indicated, the discussion centers on acute PID.

Problems of Defining PID

Although every physician is aware of what is meant by the term "pelvic inflammatory disease," usually salpingitis, it implies much more. The term clearly falls short of being descriptive of the conditions that occur in an individual patient. As the infectious process, which may be incited by a sexually transmitted pathogen such as *Neisseria gonorrhoeae* or *Chlamydia trachomatis*, ascends above the level of the endocervix, endometritis may occur concomitantly with salpingitis or may simply represent an intervening step.

Further, involvement of the peritoneum may result from extension of the infectious process beyond the fimbrial stoma of the tubes. Serious sequela of tuboovarian abscess may occur. The patient presenting with pelvic pain may have any or all of these pelvic organs involved. However, the catch-all term of PID unfortunately does not adequately identify anatomically what is infected.

The ability to establish the extent of the disease and the severity of pelvic involvement is clearly important for a rational approach to therapy. In addition, the various stages of PID should be distinguished from other conditions such as appendicitis or ectopic pregnancy. The diagnosis of PID is notoriously inexact; therefore clinical observation, careful examination of the patient, and in some instances laparoscopy aid the diagnosis.

Attempts have been made to provide a more precise description of the disease, which has led to the development of a staging system suggested by Hager and associates.[1] They suggested different systems of staging depending on whether the diagnosis is based on an examination that includes laparoscopy or it is based on clinical observation alone. This grading system is summarized in Table 7-1. Although it is important to provide a relatively standardized classification of individual PID cases, it remains to be established what the classification means in terms of preservation of fertility, the likelihood that surgery is required, the probability that medical therapy is adequate, or what antibiotic therapy is most appropriate. It must be emphasized, however, that before any relation between outcome and stage of disease can be established, gynecologists should adopt some grading system. Whether grading PID according to this or any other classification will find wide acceptance is unknown.

Populations at Risk

It is not possible to establish the diagnosis of PID in any individual case on the basis of history or demographic information, although epidemiologic data are useful for identifying groups of women at greatest risk for PID. Thus it is possible to state that certain populations are at the greatest risk for having PID. Such epidemiologic data are set forth in detail in other reports[2,3] and are only briefly summarized here. First, it should be emphasized that acute PID occurs in sexually active women. Women who have had a previous episode of PID are candidates for a subsequent attack. For example, Westrom[4] observed that 23% of women with acute PID would have a further episode. In addition, one must realize that a prior episode of gonococcal infection even without signs of salpingitis, represents a risk factor, as that episode may have been accompanied by subclinical salpingitis.

Several other demographic characteristics of the population at risk may be substantially interrelated and overlapping. They include habitation pattern (with single women living alone at greatest risk) and youth (with most cases occurring between the ages of 16 and 24). If corrections are made for sexual experience, the age group of highest incidence may be 15 or less if the population

TABLE 7-1. Grading system for salpingitis based on the recommendations of Hager et al.[1]

Clinical observations		Laparoscopic observations	
Grade	Criteria	Grade	Criteria
I (uncomplicated)	Limited to tube(s) and/or ovaries, tubes mobile with or without pelvic peritonitis	Mild	Tubal erythema, edema, no pus expressed on tubal manipulation
II (complicated)	Inflammatory mass or abscess involving tube(s) and/or ovaries with or without pelvic peritonitis	Moderate	Gross pus evident, more edema, erythema; tubes may be immobile; nonpatent fimbrial stoma possible
III (spreading)	Disease process extends to extrapelvic structures, i.e., ruptured abscess	Severe	Pyosalpinx or inflammatory complex; abscess

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is sexually active.[5] Multiple sexual partners and sex with males who have untreated infection also contribute to risk.

Intrauterine contraceptive devices (IUDs) have been implicated as increasing the danger of acquiring PID. The risk may be further enhanced by the specific type of IUD. In contrast, the use of barrier methods of contraception appears to diminish the relative risk of PID, as does the use of oral contraceptives (compared to no contraception). The role of contraception in PID risk is discussed in greater detail elsewhere.[2]

Pathogenesis

It would be of great benefit to the clinician to know precisely which organisms are involved in each case of PID, the mechanism by which they cause damage to the various anatomic structures, the mechanism whereby they spread from one anatomic site to another, and the time course of such spread. Some of these desired areas of information elude study, and other details have merely been deduced from indirect observation.

The disease process in PID is primarily intraabdominal, and as a result, observation requires laparoscopy. Essentially, only one opportunity for laparoscopy exists in most patients, although Paavonen's group[6] performed a second-look laparoscopy after therapy to establish tubal patency and the extent of adhesions 15–45 weeks after therapy. If most patients studied are to undergo only one laparoscopy, sequential changes occurring in the pelvis are not observable. Moreover, laparoscopy serves primarily to provide a gross view of the tissues; and although samples for culture may be obtained through the laparoscope, identification of microorganisms is not synonymous with establishing the cellular and molecular mechanisms of pathogenesis. These limitations must be borne in mind throughout the subsequent discussion.

Contemporary understanding of the disease process indicates the natural history of disease as lower tract infection followed by upper tract invasion. The inciting infection is usually one of the sexually transmitted diseases, e.g., gonococcal or *Chlamydia trachomatis* infection. The role of mycoplasmas in eliciting PID is more controversial. Upper tract invasion is not limited to these organisms, however, and usually involves bacteria typically found as part of the indigenous flora of the vagina and cervix.

Historically, PID was considered to be the consequence of primary gonococcal infection that ascends by contiguous spread across the endometrium at the time of menstruation and secondarily infects the fallopian tubes. Although we are now cognizant of the role of other microorganisms in PID, the ability of the gonococcus to damage tubal epithelium is clear. Organ culture of isolated tubes infected with the gonococcus has demonstrated the primary attachment to ciliated epithelium,[7] a process that depends on pili and a specific outer membrane protein of the microorganism.[8,9] The bacteria then pass through the cell layer via an endocytotic process by the epithelial cells and are extruded at the base of the cells.[10] The production or presence of lipopolysaccharide (endotoxin) as a constituent of these gram-negative bacteria as well as a peptidoglycan component appear to act locally to induce cellular damage and sloughing of ciliated cells.[11,12]

Despite the older perception that PID represents a complication of gonococcal infection, antibiotics effective against the gonococcus do not uniformly cure PID. This observation eventually led investigators to culture the intraabdominal sites of infection. The culture based verification of the nature of the intraabdominal infection is also essential because of the finding that not all patients with abdominal symptoms have positive endocervical cultures for *N. gonorrhoeae,* which suggests that this organism was not necessarily involved in abdominal symptoms.

In addition to the gonococcus, *C. trachomatis* has proved to be an important primary pathogen in the female genital tract and may serve as an antecedent of PID in a manner that appears to be similar to the gonococcus. The invasion of the upper tract may be somewhat slower when *Chlamydia* is involved because its replication cycle is slower than that of the gonococcus. Chlamydial damage has been proposed by Gjonnaess and co-workers[13] to involve an immunologic mechanism of damage rather than direct cell killing.

Chlamydia trachomatis is an obligate intracellular parasite and cannot be cultivated on standard microbiologic media, but it is grown in cell culture. Chlamydial culture is not available in all hospital laboratories but may be obtained by sending specimens to outside commercial laboratories. Immunofluorescence tests and enzyme-linked immunosorbent assays (ELISA) are available for detection of chlamydial antigen in clinical specimens and may prove to be more widely accepted for diagnostic purposes than cell culture methods, although the latter remains the highest standard for diagnosis. Epidemiologic studies indicate that chlamydial infection of the lower genital tract is more prevalent than gonococcal infection, but because of diagnostic considerations noted above, it is less often accurately identified than *Neisseria gonorrhoeae*. Those clinicians who do not have access to objective diagnostic tests may diagnose and treat patients on the basis of the presence of mucopurulent cervicitis. Because chlamydial infection is not consistently identified it may produce cases of PID that might have been prevented if adequate attention had been given to its diagnosis and therapy. Finally, it should be noted that a significant number of individuals with gonorrhea may have concomitant chlamydial infection.[14]

Mycoplasma hominis and *Ureaplasma urealyticum* may be found in the female genital tract, increasing in prevalence as sexual activity and number of sexual partners escalate. Some investigators[15] have recovered these organisms from tubal cultures in patients with PID, although the organisms' role as etiologic agents in the disease remains to be firmly established. Despite the uncertain role of these organisms it is inappropriate to ignore them when considering antibiotics appropriate for therapy of PID.

Historically, attempts have been made to establish how these primary inciting organisms cause upper tract disease by obtaining intraabdominal cultures. Importantly, the result of such studies indicate that organisms that are members of the normal flora of the lower genital tract are consistently found in the presence of upper tract disease, even when the organisms usually considered to be primary pathogens are not found. Culdocentesis represents one of the simplest methods for obtaining intraabdominal culture samples but is controversial because the actual site of infection is not sampled. Thus laparoscopy and laparotomy remain the only methods for accurately assessing the microbiologic aspects of tubal infection. Moreover, such studies have indicated that endocervical and intraabdominal cultures are frequently discordant with respect to the gonococcus, *Chlamydia,* or *Mycoplasma.* This fact emphasizes the importance of direct tubal culture for establishing the etiology of PID.

In a laparoscopic study, Sweet and coworkers[15] found that the gonococcus was isolated in about one-fourth of patients and that anaerobic bacteria were common. Mycoplasmas were rarely isolated, and chlamydiae were not found. In a subsequent study Sweet and colleagues[16] found that tubal and endometrial cultures provided 39% and 24% recovery rates of the gonococcus and *Chlamydia,* respectively; but, again, aerobic and anaerobic bacteria were present in most of the cultures. Such studies have profoundly influenced the medical therapy of PID. No longer is therapy directed at the gonococcus or *Chlamydia;* rather, the therapy is designed to deal with the aerobic and anaerobic organisms that arise from the lower genital tract as well as the chlamydial and gonococcal pathogens.

The relation between gonococcal infection of the lower tract and the types of bacteria

TABLE 7-2. Summary of bacteriologic studies of intraabdominal cultures in women with and without endocervical gonorrhea

Diagnosis	No. of patients or cultures	Percent
Endocervical gonorrhea	143/251	57
Intraabdominal gonococcus	41/251	16
Intraabdominal gonococcus plus aerobes and anaerobes	34/251	14
Intraabdominal aerobes and anaerobes only	73/251	29

Data summarized from refs. 15, 17–21.

found intraabdominally is illustrated in Table 7-2, which summarizes the microbiologic findings from six studies,[15,17–21] further emphasizing the fact of the presence of normal-flora organisms in the upper tract.

Despite the findings of lower tract normal flora organisms in intraabdominal cultures, there is still controversy about whether (1) the primary sexually transmitted organisms first infect the endometrium and tubes followed by normal-flora organisms as secondary invaders or (2) normal-flora organisms of the lower tract invade simultaneously with the sexually transmitted organisms. Although many investigators have expressed opinions, a definitive study to answer this question is still needed.

One area that has not received much attention in the past was infection of the endometrium. It was generally believed that the presence of microorganisms, particularly those that are sexually transmitted, in the endometrium represented a transient phenomenon. Nevertheless, interest in endometrial sampling is increasing for several reasons. Sampling devices are now available that minimize contamination from the endocervical flora. The endometrium is also an effective site from which to recover *Chlamydia,* and in many cases the endometrium remains culture-positive as acute salpingitis is developing.

Clinical Diagnosis

The suspicion of the presence of PID in any of its various stages is almost always the result of clinical observation, and frequently the diagnosis can be based solely on clinical features coupled with diagnostic acumen. It seems reasonable that if a diagnosis can be made on the basis of clinical and laboratory criteria, thereby allowing institution of adequate therapy, the need to resort to laparoscopy is obviated.

A sophisticated study by Hadgu and co-workers[22] defined the relative merits of various clinical and laboratory observations in predicting the presence of salpingitis. The data for this study, collected from 1960 to 1967, suggested that clinical observation may be used to aid the clinician in limiting laparoscopy to those situations in which it is most likely to enhance the diagnostic accuracy. This study confirmed the diagnosis by laparoscopic visualization, and multivariate logistic regression analysis was used to identify those nonsurgical observations that served as good predictors of PID. The strongest predictors were purulent vaginal discharge, erythrocyte sedimentation rate (ESR) above 15 mm/hr, and positive *N. gonorrhoeae* culture. The study did not include culture or immunologic detection methods for *Chlamydia* or *Mycoplasma,* which may have contributed to the utility of the model. The data obtained indicate that it is possible to examine select patients on the basis of clinical parameters for further study with laparoscopy to ultimately achieve a high degree of diagnostic accuracy. It should be feasible to use clinical parameters and limited laparoscopy as well as contemporary chlamydial detection systems and the mathematic models of Hadgu and co-workers[22] to idealize the diagnosis of PID.

In an attempt to provide some standardization for diagnosis of PID, Hager et al.[1] provided clinical criteria, summarized in Table 7-3. A significant number of PID cases are diagnosed on clinical grounds, but clinical and laboratory findings are not sufficient

TABLE 7-3. Criteria for clinical diagnosis of salpingitis

All of the following must be present
Abdominal direct tenderness with or without rebound tenderness
Cervical and uterine motion tenderness
Adnexal tenderness
One of the following must be present
Endocervical Gram stain consistent with gonococcus
Positive fluorescent antibody or culture for *Chlamydia trachomatis*
Temperature >38°C
Leukocytosis >10,000/mm^3
Leukocytes present in culdocentesis fluid
Pelvic abscess or complex on bimanual or sonographic examination

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to diagnose all cases. When in doubt, laparoscopy is an appropriate choice for women with pelvic pain who have not been sexually active for some time, or for those who have a chronic disease process. Despite the careful application of clinical observation coupled with objective tests, the definitive diagnosis of salpingitis requires laparoscopic observation of the pelvic structures. This finding has been underscored by investigators who compared the standard criteria for salpingitis with laparoscopic findings. The conclusion drawn from such studies is that diagnosis of salpingitis on the basis of clinical and laboratory criteria is limited, and misdiagnosis remains a significant possibility.

Diagnostic Pelviscopic Surgery

The history of our understanding of PID is one in which laparoscopy has played a significant role. This role is twofold. First, until laparoscopy was employed, identification of the organisms responsible for salpingitis and peritonitis were only a matter of conjecture. Second, without direct observation of the involved structures one could not accurately ascertain the extent of the inflammatory process. Although pelvic endoscopy is not the only way to diagnose PID, it is the only way to visualize the pelvic structures.

Laparoscopy should not become an alternative to careful consideration of the clinical picture. In recognition of these facts, Eschenbach[23] emphasized the subjective and objective criteria that accompany the diagnosis of acute salpingitis. The patient must have a history of lower abdominal pain with or without evidence of rebound tenderness, cervical motion tenderness, and adnexal tenderness. In addition, one of the following objective criteria must be present: temperature above 38°C, leukocytosis above 10,500/μl, culdocentesis yielding fluid with white blood cells and bacteria, a pelvic mass revealed by palpation or ultrasonography, an elevated ESR, or a positive test for *N. gonorrhoeae* or *C. trachomatis* in the endocervical secretions.

It is important to clearly establish what the surgeon gains by performing laparoscopy in the patient suspected of having acute PID. Although the true microbiologic picture of PID can be verified only by laparoscopically directed culture, it is appropriate to raise the question of whether it is always necessary to perform laparoscopy to determine the appropriate antibiotic regimen. Clearly, it is not. The results of the studies described above have allowed the development of guidelines for therapy that are rational and provide coverage for the microorganisms most commonly associated with pelvic inflammatory infection. In the future, additional microbiologic studies will also be warranted because the ecology of infections is subject to change, and adequate documentation of these changes is vital. Nevertheless, it should be emphasized that, although it is not necessary to perform laparoscopy solely for the sake of obtaining a culture, if laparoscopy is performed for reasons of diagnostic uncertainty it is desirable to use this opportunity to take intraabdominal samples for culture.

The most common indication for laparoscopy in the patient who may have PID is uncertainty about the diagnosis. The features that may be observed in such patients are noted in Table 7-1. Although direct observation may allow one to rule out certain disease processes, a substantial number of patients—approximately one-fifth according to some estimates[23]—have a normal pelvis.

Jacobson and Westrom[24] discussed the diagnostic and prognostic value of laparoscopy in patients with acute PID. They reviewed 905 cases from the early 1960s in which a provisional diagnosis was established on the basis of acute lower abdominal pain, fever, menstrual irregularity, vaginal discharge, urinary symptoms, proctitis, pelvic tenderness on bimanual examination, a palpable mass or swelling, or a combination of these factors. Visual diagnosis of acute salpingitis depended on marked hyperemia of the tubal surface. Thus if there had been hyperemia of the mesosalpinx with edema of the tubal wall, the patient was considered to have acute salpingitis. Furthermore, if there was an exudate on the tubal surface or emanating from the fimbriated end of the patent tubes, a diagnosis of PID was made.

Jacobson and Westrom[24] indicated that laparoscopic visibility was adequate in 99% of their patients, and the procedure resulted in no significant operative complications. The clinical diagnosis of salpingitis was applied to 815 of the women they studied, but laparoscopy confirmed the diagnosis in only 512 (65%). An additional 184 patients had no demonstrable pathology, and 98 women had clinical entities other than salpingitis. Interestingly, unsuspected acute salpingitis was discovered in 91 patients. Diagnosis based solely on clinical criteria proved erroneous because of acute appendicitis, pelvic endometriosis, or intrapelvic hemorrhage. Most patients with visually verified salpingitis reported two or three symptoms, although 13% had only one symptom. The most common finding upon admission was marked adnexal tenderness on bimanual examination. Approximately one-third had fever, but the ESR was not consistently elevated. Although these data were obtained two decades ago, the authors concluded that laparoscopy fulfilled the demands for a safe, simple, highly accurate diagnostic procedure for gynecologic diagnosis.

If other clinical findings are essentially negative, the patient with chronic pelvic pain is a candidate for laparoscopy. The ability to visualize the intraabdominal structures can be invaluable in such cases, although the distinction between chronic pelvic sepsis and endometriosis may be difficult to make. With some cases of chronic pelvic pain there is no obvious pathology, but there is a suspicion that pelvic congestion, colonic spasm, or other entity related to stress and nervous tension is responsible. Many gynecologists find that a valuable function of the laparoscope is not to confirm the presence of a disease but to exclude the presence of organic disease in patients with distressing symptoms and apparently normal organs. At the same time there may be a temptation to resort too early to this approach than to adequately analyze the clinical features.

When functional disturbance of the bladder or bowel is suspected, excretory discipline and antispasmotic drugs should be prescribed in the first instance. In some cases the woman's life style should be altered; and for others, in whom the cause of stress is less clear, symptomatic remedies may be offered. When such measures prove unsuccessful, it may reassure both patient and physician if a series of negative clinical findings is complemented by a careful laparoscopic examination of the abdomen and pelvis.

In the United States routine laparoscopy for patients with suspected acute PID has not been generally accepted. The reason is that most patients are not admitted to the hospital, and there are currently insufficient operating room facilities available for laparoscopy on this scale. An estimated 2.5 million physician visits are occasioned in the United States by PID, and the logistics of a substantial increase in the number of laparoscopies performed could cause significant upheavals in the present health care delivery system.

If changes in the medical infrastructure occur, such as an increase in the availability of operating rooms for outpatient laparoscopy or outpatient surgical centers, an expanded role for laparoscopy in the diagnosis of PID could be envisioned. However, physicians would likewise need to avoid the temptation to overuse the procedure. Given the current attention being paid to sexually transmitted disease, some institutions are already increasingly prone to admit patients for salpingitis and to resort to laparoscopy.

In conclusion, it is important to reemphasize the fact that much has been learned about the relation of clinical symptoms to intraabdominal pathology from laparoscopic studies. The same may be said about understanding the microbiology of PID. However, it should be stated that it probably is not necessary for the gynecologist engaged in routine patient care to use laparoscopy with the same frequency as those engaged in research activity. In fact, the investigation of Hadgu and co-workers[22] indicated that laparoscopic investigations should be limited to identifying parameters that cannot be evaluated clinically, thereby allowing laparoscopy to be used less frequently but more effectively. The most important use of laparoscopy today is among women in whom the diagnosis is associated with doubt, particularly patients who have received several courses of antimicrobial therapy for pelvic pain. Some of these women have other entities, including pelvic adhesions or endometriosis, that explain the failure of antibiotics.

Options for Medical Therapy

There are numerous therapeutic regimens applied to treat salpingitis and many applied to treat tuboovarian abscess. The myriad single- and multiple-drug combinations employed have been reviewed by Burnakis and Hildebrandt,[3] and the reader desiring a comprehensive summary of the literature is directed to that source.

The basis for selecting a rational therapy is twofold and considers if the patient is hospitalized and what offending organisms are involved in the disease process.

Therapy of an outpatient differs markedly from that of an inpatient. Inpatient therapy usually consists in parenteral drugs given to a patient who is taking nothing by mouth because she is a potential candidate for surgery and because of the efficacy of this mode of treatment. Furthermore, a wider selection of antimicrobial drugs is available when parenteral therapy is employed. Occasionally it is advisable to employ inpatient therapy in the young woman who may be at risk for noncompliance with outpatient therapy. Hospitalization also allows the close monitoring of the efficacy of therapy. The obvious incongruity is the current emphasis on increasing the number of patients managed as outpatients and reducing hospital admissions and length of hospital stay. At the same time, it seems prudent to pursue a policy of readily admitting the patient with PID and treating the disease aggressively, especially in women in lower socioeconomic groups and of lower educational status. This group of patients, who may need close observation in the hospital, may also require some public assistance program, and therefore hospital costs may not be fully reimbursed.

The second consideration when planning therapy is the specific microorganisms typically involved in acute salpingitis. The list of organisms isolated from culdocentesis and laparoscopically derived materials is large; an abbreviated version is presented in Table 7-4. It is these organisms that are considered most likely to be part of the pathologic process. It is well known that a significant number of cases occur in which the sexually transmitted organisms are isolated only from the lower genital tract. In addition, sexually transmitted organisms are frequently seen early in the disease process but may not be isolated later. This finding has led some investigators to propose that PID is a biphasic process in which early damage is caused by a sexually transmitted organism that predisposes to a secondary infection caused by the lower tract normal flora. There does seem to be a greater chance of obtaining positive cultures for *N. gonorrhoeae* during the first 24 hours of symptoms

TABLE 7-4. Organisms most commonly isolated from intraabdominal cultures or women with PID

Sexually transmitted	
	Neisseria gonorrhoeae
	Chlamydia trachomatis
	(*Mycoplasma hominis*)
	(*Ureaplasma urealyticum*)
Nonsexually transmitted aerobes (facultative)	
	Gardnerella vaginalis
	Escherichia coli
	Nonhemolytic streptococci
	Group B streptococci
Nonsexually transmitted anaerobes	
	Bacteroides bivius
	Other *Bacteroides*
	Peptococcus asaccharolyticus
	Peptostreptococcus anaerobius

Based on Landers and Sweet.[2] Reprinted with permission.

TABLE 7-5. CDC guidelines for treatment of acute PID

Inpatient therapy
Cefoxitin (2 g IV q6h) *plus*
Doxycycline (100 mg IV q12h) for 4 days minimum and at least 48 hours after defervescence *then*
Doxycycline (100 mg PO daily for 10–14 days)
or
Clindamycin (600 mg IV q6h) *plus*
Gentamicin or tobramycin (2 mg/kg IV, then 1.5 mg/kg IV q8h)
Continue for 4 days minimum and for at least 48 hours after defervescence *then*
Clindamycin (450 mg PO qid for 10–14 days)
or
Doxycycline (100 mg IV q12h) *plus*
Metronidazole (1 g IV q12h)
Continue for 4 days minimum and for at least 48 hours after defervescence *then*
Continue both drugs at the same dose orally for 10–14 days
Outpatient therapy
Cefoxitin (2 g IM) *or*
Aqueous procaine Pen G (4.8 million units divided between two IM sites) *or*
Amoxicillin (3 g PO) *or*
Ampicillin (3.5 g PO) *plus*
Probenecid (1 g PO) *then*
Doxycycline (100 mg PO twice daily for 10–14 days) *or*
Tetracycline HCl (500 mg PO qid for 10–14 days)

than when cultures are obtained later.[15] Many investigators believe that both sexually transmitted and endogenous organisms tend to infect the upper tract simultaneously even though the sexually transmitted organisms may play an ephemeral role.

The guidelines of the Centers for Disease Control (CDC) for therapy of acute salpingitis are presented in Table 7-5. These guidelines cover the major groups of microorganisms believed to be important in the disease process. Much testing is needed to establish the superiority of these treatment protocols to others that might be employed, but at present these guidelines may be taken as the minimal therapy for salpingitis.

Although penicillins have been used traditionally because of the role of the gonococcus, the presence of other organisms in the upper genital tract coupled with the emergence of penicillinase-producing *N. gonorrhoeae* has served to diminish their utility. *Bacteroides,* particularly *B. fragilis,* may produce β-lactamases as well. Moreover, single-agent therapy tends to provide inadequate resolution of symptoms and may predispose to abscess formation. Tetracyclines have obtained a place in the therapy of PID because they are active against both the gonococcus and *Chlamydia,* although a few strains of *N. gonorrhoeae* are tetracycline-resistant.

Second-generation cephalosporins, particularly cefoxitin, are employed in the combination of drugs used for therapy of PID because of the broad spectrum of activity that includes coverage of anaerobes. Clindamycin and metronidazole are also employed for their inhibitory effect against anaerobes. It should be borne in mind that tetracyclines have inadequate activity against most *B. fragilis* strains, and the aminoglycosides have no activity against the anaerobes.

A further problem with the medical therapies promulgated for treatment of PID is the lack of information on the length of time therapy must continue. Intimately related to this issue is the method for determining efficacy of antibiotic therapy. Attempts have been made to objectively evaluate the symptoms (Table 7-6). The clinician is initially concerned about defervescence and diminution of pain and other symptoms. However, other issues related to long-term sequelae are less often considered as part of the evaluation of therapeutic efficacy. They include subsequent fertility and the development of intraabdominal adhesions or abscess formation. The use of objective criteria for grading the severity of the acute disease process coupled with careful evaluation of future fertility should be used in future studies to assess therapeutic success.

Medical therapy for tuboovarian abscess represents a final and perhaps the most controversial area that should be addressed in this discussion of therapy. The presence of an abscess has traditionally been considered a surgical problem and in the past has occasioned laparotomy, hysterectomy, and oophorectomy. With recognition of the role of anaerobic bacteria in tuboovarian abscess and with potent antibiotics that can reach significant levels in the poorly perfused abscess, medical treatment for tuboovarian abscess has become a credible option. A more extensive review of this subject, published elsewhere, revealed that a significant number of abscesses may be treated medically.[26]

TABLE 7-6. Method for assessing the severity of PID symptoms

Criterion	Maximum score
Tenderness in each abdominal quadrant	0–3 × 4 = 0–12
Rebound tenderness in each abdominal quadrant	0–3 × 4 = 0–12
Pelvic examination	
Cervical motion tenderness	0–3
Uterine tenderness	0–3
Adnexal tenderness (each)	0–3 × 2 = 0–6
Liver tenderness	0–3
Mass(es)	0–3
Total	0–42

Each clinical criterion is given a score of 0 (least) to 3 (worst). The total score is calculated to give a maximum of 42.
Improvement is a decrease in score of 70% over 3–7 days.

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Yet this therapy is not uniformly successful. The success of this approach probably requires early aggressive therapy before the abscess becomes massive. Good anaerobic coverage as well as antibiotic coverage of the gram-negative facultative organisms is also essential. In the experience of Landers and Sweet,[26] approximately 15% of women treated medically for tuboovarian abscess became pregnant after resolution of the abscess.

The Future

It may be useful to contemplate the future of laparoscopic assessment of PID. It seems clear that in the United States the role of laparoscopy in relation to PID will probably increase. Yet as studies demonstrate the efficacy of new diagnostic modalities, the use of laparoscopy may become more selective. The use of this method for operative procedures may also be contemplated as described by Reich and McGlynn[27]. The role of serum components, e.g., acute-phase reactants or perhaps specific antibodies that suggest invasion by particular organisms, could become more important in the future and would consequently make it unnecessary to resort to laparoscopy. New imaging techniques may in some cases supplant invasive diagnostic techniques. In any case, the physician must now use wisely the available tools and in the future be prepared to use new methods to provide the optimal care for a disease process fraught with diagnostic and therapeutic difficulty.

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8
Endoscopic Management of Tuboovarian Abscess and Pelvic Inflammatory Disease

HARRY REICH

Treatment of infertility is glamorous gynecology. Treatment of pelvic inflammatory disease (PID), the most important preventable cause of infertility, afflicting an estimated 1 million American women yearly, is not glamorous gynecology . . . [and] must be one of the most neglected areas of American medicine.[1]

In recent years the accepted therapy for an unruptured tuboovarian abscess has been intravenous antibiotics. Surgical intervention was considered only when it appeared that the patient was not responding to antibiotics.[2] This approach leaves the necrotic and inflammatory tissues in prolonged contact with each other, which is likely to result in the formation of chronic, dense, fibrous adhesions with resultant impaired reproductive potential, an occurrence routinely observed by many laparoscopists in clinical practice. Laparoscopy with lysis of acute adhesions may prove to be a better alternative than antibiotic therapy alone.[3]

The belief that surgical intervention during acute pelvic infection results in greater injury than waiting for the infection to subside is based on a New York City study published in 1909 that suggested increased surgical technical difficulty.[4] In fact, it is much easier to operate on acute adhesions. Second-look laparoscopic adhesiolysis soon after infertility surgical procedures is much easier than the original procedure. Electrosurgery, laser surgery, and sharp scissors dissection, each of which proves useful during surgery for chronic PID, have no place in the treatment of acute pelvic abscess. Laparoscopic treatment of acute PID with or without abscess does not require the highly technical laparoscopic skill necessary to excise an endometrioma, open a hydrosalpinx, or remove an ectopic pregnancy.[5–7] It is essentially an exercise in careful blunt dissection using a blunt probe or "aquadissection" with an Aquapurator (WISAP, Sauerlach, West Germany) and can be performed by many gynecologists experienced in operative laparoscopy using equipment generally available in most American hospitals.

This chapter addresses the use of the laparoscope for the definitive diagnosis of acute PID. Results of medical antimicrobial therapy and laparoscopic treatment for tuboovarian abscess are detailed. Laparoscopic surgical technique for the treatment of tuboovarian and pelvic abscess is described, followed by the laparoscopic treatment of acute salpingitis and ruptured tuboovarian abscess—the beginning and end of the spectrum involving tuboovarian abscess. Finally, why laparoscopic treatment works is discussed, and economic considerations are illustrated. The terms tuboovarian abscess and pelvic abscess are used interchangeably, with pelvic abscess implying extension of the tuboovarian abscess to involve most of the true pelvis.

Laparoscopic Diagnosis

The routine use of laparoscopy to diagnose acute PID has become widespread in Europe and is accepted by every gynecology department in Sweden[8,9] (see Chap. 7). Following Sjovall's initial work,[10] Jacobson and Westrom[11] clearly documented the value of laparoscopy for the diagnosis of acute PID. In their 1969 report of 814 women with suspected acute PID, the diagnosis was confirmed at laparoscopy in only 65% of cases. In 12% of cases, laparoscopy revealed other pathologic conditions including acute appendicitis, endometriosis, hemorrhagic corpus luteum, ectopic pregnancy, ovarian tumor, and chronic salpingitis. Twenty-three percent of women had no pelvic pathology present, as noted in Chapter 7. In an additional 91 women laparoscoped during the same time frame (1960–1967), acute PID was found unexpectedly at laparoscopy for suspected ovarian tumor, acute appendicitis, ectopic pregnancy, chronic salpingitis, endometriosis, and uterine myoma.

Binstock and colleagues have reviewed the laparoscopic findings in 1901 patients with a clinical diagnosis of PID from ten clinical reports[12–21]: Acute PID was confirmed in 62% of cases (range from 46%–73%). No pelvic pathology was observed at laparoscopy in a mean 20% of cases. Other studies have confirmed these results.[22,23] These studies were performed by gynecologists at medical centers located in large metropolitan areas.

Acute salpingitis is often diagnosed and treated by other health care professionals, especially family practitioners. This author has had the opportunity to laparoscope 20 consecutive women who were not responding to intravenous antibiotic therapy following admission with a diagnosis of acute PID to a small community hospital with no gynecologist on staff. Acute or chronic salpingitis was found in three women and various stages in the physiologic ovarian cyst cycle were found in the others. Similar results were observed in the author's hospital: Acute PID was laparoscopically diagnosed in fewer than 20% of women admitted with that diagnosis by family practitioners. Many of these referred patients had pain, pyrexia, cervical tenderness, and a mass both palpable and visible on ultrasound. One woman, treated with a 10-day course of intravenous antibiotics at a New England medical center, proved to have had a ruptured appendix, that was seen to be resolving at laparoscopy 2 weeks later. Laparoscopic bilateral tuboovariolysis and lysis of small bowel adhesions were performed, and the patient conceived 6 months later. Thus until a better diagnostic technique is developed, with the infrequency of acute salpingitis in private practice, all possible cases should be laparoscoped for definitive diagnosis.

Medical Treatment

Pelvic abscess resulting from progression of acute salpingitis is treated in most centers today with intravenous antibiotics capable of penetrating the abscess and effective against organisms present in the abscess. Antibiotic failure is usually followed by a surgical procedure: drainage, unilateral salpingo-oophorectomy, or total abdominal hysterectomy with bilateral salpingo-oophorectomy (TAH/BSO). Antibiotic success implies the resolution of symptoms and, often at a much later date, resolution of the pelvic mass as judged by clinical or ultrasound examination; it in no way implies the resolution of pelvic adhesions that could result in future infertility. The literature cited below confirms that when long-term resolution of symptoms and infertility is considered, medical treatment is often doomed to failure even with modern antibiotics.

Collins and Jansen[24] treated 174 of 298 cases of pelvic abscess (presumptive diagnosis) from 1953 to 1959 with fluid and electrolyte replacement, bed rest, nasogastric suction, antibiotic coverage, and drainage of any abscess accessible through the cul-de-sac or suprainguinal region. Of the 174 women, 161 responded to this therapy, but

113 subsequently required surgery for residual problems, mainly persistence of a painful pelvic mass, menometrorrhagia, or chronic pelvic pain. Thus more than two-thirds (126 of 174, or 70%) required surgical treatment eventually.

In 1973 Franklin and colleagues[25] reported the results of 137 consecutive cases of acute pelvic abscess seen between 1963 and 1968. Of these women, 120 underwent conservative management that included 35 posterior colpotomies (9 day average hospital stay); ten underwent laparotomy because of a question of the primary diagnosis, and seven underwent immediate surgery because of a pelvic abscess that was thought to be ruptured. Of the 120 cases treated conservatively, 103 were followed for 2.5–8.0 years. Twelve women (10%) required definitive surgery, usually hysterectomy and adnexectomy for "early failure" to respond to conservative management during their initial hospitalization, and 19 (16%) required subsequent definitive surgery for persistent mass, pain, or hypermenorrhea, for a total failure rate of 26%. Among the 120 women, 10 subsequently conceived (8%).

More recently, Ginsburg and colleagues[26] reviewed 160 patients with an admitting diagnosis of tuboovarian abscess (1969–1979). Of these women, 76 responded to medical therapy with no subsequent surgery, 34 underwent later surgery for persisting symptomatology related to the abscess, and 50 required surgery during the acute phase because of failure to respond to the medical regimen (40 TAH/BSO, 4 unilateral adnexectomies, and 6 abscess drainage procedures). Eighty percent of the women who responded to medical therapy and had no subsequent surgery continued to experience persistent or recurrent disease. Of 120 women in whom reproductive function was preserved, 9 conceived (7.5%); no women with a bilateral tuboovarian abscess conceived.

Hager[27] (1970–1974) also documented poor success with medical therapy alone. Of 143 cases of PID, tuboovarian abscess was initially diagnosed in 50. Of the 93 without clinical abscess, 86 (92%) responded to medical treatment and 7 required surgery after failure of medical treatment (five of the seven had an undiagnosed tuboovarian abscess). Of the 50 with the original diagnosis of tuboovarian abscess, only five were deemed to have had successful medical treatment. Twenty-seven women required surgery after medical treatment failure, and 18 women underwent initial surgical treatment. Hager reported that response to antimicrobial therapy may be the most reliable way to distinguish women with salpingitis only from those with salpingitis plus a tuboovarian abscess, as the latter group did not respond well to antibiotic treatment alone.

In 1983 Landers and Sweet[28] reported their results of 175 of 232 women with tuboovarian abscesses treated with antibiotics alone. Laparoscopic confirmation was performed in only 15 of these women. Twenty-five percent required surgery as part of their original therapy, including 8 of 71 women initially treated with regimens including clindamycin. Reduction in the size of the tuboovarian abscess was noted at the time of discharge in 38 of 104 women (36.5%) treated with an antimicrobial regimen that excluded clindamycin. Further reduction in the size of the abscess was noted 2–4 weeks after discharge in 39 of 84 (46%). However, reduction in the size of the abscess at hospital discharge was noted in 43 of 63 women (86%) who received an antimicrobial regimen that included clindamycin; 43 of 50 in this group demonstrated further reduction in the size of the tuboovarian abscess at 2–4 weeks after discharge. Long-term follow-up information was available for 58 women treated with antibiotics alone: 31% required subsequent surgery.

Hemsell and associates[29] reported 41 women with pelvic abscesses complicating salpingitis who were treated with cefotaxime during 1980–1981. All women responded to therapy, with two requiring the addition of another antimicrobial (chloramphenicol). Chronic pelvic pain and recurrent infection were infrequent during a 31- to 43-

month follow-up period, but five women (12%) subsequently required TAH/BSO for a persistent adnexal mass, and a sixth underwent unilateral salpingo-oophorectomy for an asymptomatic adnexal mass (hydrosalpinx). A pregnancy rate of 20% (6 of 30) was observed.

Diagnosis in the above and other studies[30] was based on clinical and sonographic findings; rarely was laparoscopy used for diagnosis or later evaluation. These studies document a trend toward extensive pelvic adhesions with resultant pelvic masses (hydrosalpinx). It can be surmised that rarely does antimicrobial treatment of a formed tuboovarian abscess result in complete resolution without adhesion formation. In addition, medical treatment resulted in prolonged initial hospitalization in most cases with a high rate of readmission. In addition, medical treatment has not proved beneficial in ensuring fertility and can be justified only because ovarian preservation results in the possibility of a future in-vitro fertilization procedure.

Surgical Treatment

Primary surgical treatment (laparotomy) for an unruptured tuboovarian abscess within a few days of admission has always been controversial. Early TAH/BSO was advocated by Kaplan and associates[31] who, during 1964–1966, treated 71 women with a presumptive diagnosis of pelvic abscess in this manner following no response (10% of patients) or only partial response (80% of patients) within 72 hours of admission. They identified the 10% of patients with a "complete response" as a group who probably never had an abscess. Five patients received more than 2 units of blood. Postoperatively, there were seven superficial wound infections, one subfascial wound, and one evisceration. Cuff abscess occurred in three women.

Colpotomy drainage can be performed for those pelvic abscesses dissecting into the upper portion of the rectovaginal septum. Many of the reports previously cited under medical treatment included colpotomy drainage when possible. Rubenstein and colleagues[32] reported in 1976 the results of 38 colpotomy procedures for pelvic abscess. Mean duration of hospitalization was 12.4 days (7.7 days after drainage). Four women (11%) had rapid progression of infection after drainage and required emergency hysterectomy with bilateral salpingo-oophorectomy during the original hospitalization. Two other women had major surgical procedures during the initial hospitalization: one unilateral salpingo-oophorectomy and one second colpotomy. Eight women (21.6%) had a subsequent hysterectomy and salpingo-oophorectomy for continuing pain, recurrent infection, or persistent mass. Therefore, among 38 women 14 (37%) required additional surgery after being treated by antibiotics and colpotomy. Two other patients had significantly increased morbidity. Eighteen women were followed for at least 1 year after drainage: Eleven (61%) remained asymptomatic, and the other seven continued to have pelvic pain. Three of these 18 women subsequently became pregnant.

Rivlin[33] reviewed the results of 59 colpotomy drainage procedures. Further surgery during the same admission was performed in 13 cases and additional surgery at a later admission in 11 patients. Five of 40 potentially fertile women (12.5%) had successful pregnancies. Rivlin and colleagues[34] also reviewed the results of 348 colpotomy drainage procedures at two medical centers. There were 23 instances of diffuse peritoneal sepsis (6.5%) with six deaths attributable to this condition.

It has become increasingly evident that many tuboovarian abscesses are unilateral.[35] Therefore unilateral adnexectomy has become the operation of choice in these cases when antibiotics fail to produce resolution of the abscess. Landers and Sweet,[2], Golde et al.[35] Manara,[36], and Rivlin[37] have been especially successful with this approach, although later surgery was required in 16.8% of these cases. Subsequent pregnancy occurred in 14% (9 of 64).[2]

Percutaneous Drainage of Pelvic Abscess

In 1985 Van Sonnenberg and colleagues[38] reported a 78% success rate with percutaneous drainage of 50 pelvic abscesses. Gerzof and colleagues,[39] also in 1985, successfully treated six of nine pelvic abscesses (67%) via percutaneous drainage. Worthen and Gunning,[40] in 1986, reported percutaneous drainage of 35 pelvic abscesses secondary to pelvic inflammatory salpingitis. Nine patients with 11 abscesses were treated by percutaneous catheter placement, with a success rate of 77%; two required surgical procedures. Nineteen women underwent percutaneous aspiration. Among them, there were 23 abscess cavities, 18 (94%) of which were successfully aspirated; one required surgical drainage. Seven women had abscess cavities that could not technically be drained or aspirated. Four of these seven recovered on antibiotic therapy alone, and three required surgical drainage. Long-term follow-up was not part of any of these studies.

History of Laparoscopic Treatment

Laparoscopic treatment of pelvic abscess was first proposed in 1972.[41] Its successful use was documented in the 1984 report by Henry-Suchet et al.[42] of 50 women with tuboovarian abscess treated with laparoscopic surgery and intravenous antibiotics. This report was based on a continuous series of 569 women treated for laparoscopically verified acute PID during 1974–1983. Laparoscopy was performed within 24 hours of admission. Following diagnosis of a recent tuboovarian abscess in 32 cases, the friable adhesions between the pelvic organs were broken up with a blunt probe and purulent fluid completely drained with suction. Following the freeing of adnexa and bowel, the peritoneal cavity was rinsed with a mixture of physiologic saline with antibiotics (doxycycline or minocycline) and an antiseptic (noxythioline). In 18 cases with chronic dense adhesions, the bowel was mobilized from the pelvic organs, but the adnexa constituted a dense mass in which it was difficult to distinguish between the pyosalpinx and the ovary. In these cases the mass was punctured with a needle, the abundant purulent fluid removed with suction, and the saline–antibiotic–antiseptic mixture instilled into the abscess cavity; i.e., the adhesions between tube and ovary were not lysed. No drain was left in any of the 50 patients. Intravenous antibiotics were started during laparoscopy immediately after bacteriologic samples were obtained and included a combination of a cephalosporin and an aminoglycoside initially and, most recently, cefotaxime or cefoperazone, tetracycline, and metronidazole. No complications occurred during or after laparoscopic treatment.

A rapid recovery was recorded in 45 of 50 cases (90%) with complete disappearance of the adnexal mass within 3–4 days and with reduction in hospitalization from an average of 15–20 days to 6–8 days. Early laparotomy was necessary in five cases: one TAH/BSO, two bilateral salpingectomies, and two unilateral salpingo-oophorectomies. No abscess was found in the two women who underwent unilateral salpingo-oophorectomy. The procedures were performed on the basis of ultrasound data despite clinical improvement (the ultrasound mass proved to be functional ovarian cysts covered with adhesions in both cases). Thus there were only three early failures of treatment.

Long-term follow-up was possible in 44 of these women: Six (13%) experienced persistent pelvic pain. Twenty-five patients underwent a second laparoscopy which documented the absence of tuboovarian adhesions in 12 patients, unilateral adhesions in five patients, and bilateral adhesions with tubal obstruction in eight women, who later underwent laparotomy surgery for pain (three cases) or infertility (five cases).

The series included 24 bilateral abscesses: 12 recent and 12 chronic. Of the 12 women with recent bilateral tuboovarian abscess, seven had later laparoscopy, with normal adnexa reported in five and light adhesions in two. Three of these women had subsequent intrauterine pregnancies. In addition, there were three intrauterine pregnancies following treatment of unilateral abscess. No pregnancies were recorded in the chronic abscess group.

The American experience with laparoscopic treatment of tuboovarian abscess is limited. In 1981 Adducci[18] described seven patients treated by laparoscopic lysis of pelvic abscess loculations followed by colpotomy drainage under direct vision. Two other patients with bowel loops adherent to the cul-de-sac underwent laparoscopic drainage of purulent fluid followed by lysis of adhesions; Penrose drains were then placed abdominally, without laparotomy incision. Average hospitalization was 4 days, with the longest being 7 days. There were no early or late complications, and follow-up examination revealed good resolution in all cases.

Freistadt,[43] in 1985, reported the use of laparoscopy following colpotomy incision to direct the end of the Penrose drain into the abscess cavity. The drain was left in place for 2–3 days with the aid of a vaginal suture. Three of the four women subsequently became pregnant. Muzsnai's group has performed laparoscopic drainage procedures on tuboovarian abscesses in 13 patients, 12 of whom had a good clinical response.[12]

In the author's experience, from December 1976 until October 1987, 31 of 33 women with tuboovarian and pelvic abscess were treated at Nesbitt Memorial Hospital, Kingston, Pennsylvania, and Wilkes-Barre General Hospital, Wilkes-Barre, Pennsylvania, with intravenous antibiotics and a laparoscopic surgical procedure. One 37-year-old gravida 4, para 4 patient early in the study had laparoscopy for diagnosis alone and, following failure to respond to antibiotic therapy, underwent total abdominal hysterectomy. One 29-year-old gravida 1 para 1 patient, who underwent laparotomy for presumed ruptured appendix, was treated for bilateral tuboovarian abscess with preservation of all reproductive organs when the author was consulted during the operative procedure. (She has had two subsequent intrauterine pregnancies.) Of 31 laparoscopically managed cases, there were 18 unilateral tuboovarian abscesses, 9 bilateral tuboovarian abscesses, 3 diverticular abscesses, and 1 postappendectomy abscess. The average age was 28 years (range 10–61 years) with a median of 25 years. All cases were performed under general anesthesia with endotracheal intubation, and all cases performed after November 1983 were photodocumented or videotaped. Since 1983, complete lysis of pelvic adhesions was performed in all patients including chronic abscesses with dense walls. Extensive débridement of necrotic exudate was also accomplished.

Of 31 women treated for pelvic abscess, 30 (97%) had complete clinical resolution of the abscess. No laparoscopic complications occurred during the 10 years of the study. Average operating time was 90 minutes, and average length of hospital stay postlaparoscopy was 4.1 days. Minimal adhesions were found in the six women who later underwent second-look laparoscopy.

Of 27 tuboovarian abscesses, 26 were successfully treated laparoscopically with one late failure early in the series (1977), requiring TAH/BSO for persistent masses 1 month after laparoscopic treatment. Of the seven women desiring pregnancy, four had term deliveries. The remaining three women have a 4- to 8-year history of infertility that preceded their laparoscopic abscess treatment. Two women had unplanned pregnancies: One elected to have an abortion, and the other had a first-trimester spontaneous abortion.

All three cases of diverticular abscess were treated successfully with no recurrence evident after 3 years of follow-up. Second-look laparoscopy in one patient revealed minimal adhesions.[3]

A 10-year-old girl with postappendiceal abscess was treated by a laparoscopic procedure 21 days after appendectomy and 5 days after development of a peritoneovaginal fistula. She had failed to respond to parenteral antibiotics and a surgical drainage procedure. She was discharged home on the third day after laparoscopy afebrile and pain-free; she returned to full activity by the fifth postoperative day.[3]

Laparoscopic Surgical Technique

Preoperative Considerations

A woman presenting with lower abdominal pain and a palpable or possible pelvic mass should be laparoscoped to determine the true diagnosis. The importance of laparoscopy cannot be overstated: Even "obvious abscesses" may prove to be endometriomas, hemorrhagic corpus luteum cysts, or the result of a ruptured appendix. The diagnosis of tuboovarian abscess should especially be suspected in a woman with a recent or prior history of PID who has persistent pain and pelvic tenderness on examination. Fever and leukocytosis may not be present. Ultrasound examination frequently documents a tuboovarian complex or abscess. More sophisticated diagnostic testing, including gallium 67- and indium 111-labeled white blood cell scans and computed tomographic scans, are rarely necessary, as laparoscopy can determine the diagnosis. Following presumptive diagnosis, hospitalization should be arranged either on the day of diagnosis or the following morning, with laparoscopy soon thereafter.

Antibiotics

Intravenous antibiotics are initiated on admission, usually 2–24 hours prior to laparoscopy, in order to gain adequate blood levels to combat transperitoneal absorption during the procedure. Cefoxitin 2 g IV q4h from admission until discharge is frequently used. Oral doxycycline is started on the first postoperative day and continued for 10 days following hospital discharge (on the average, postoperative day 2 or 3).

Cefoxitin is a semisynthetic cephamycin antibiotic active against virtually all clinically important gram-negative facultative bacteria including *Neisseria gonorrhoeae*, gram-positive aerobic bacteria other than the enterococcus, and clinically important anaerobic organisms including *Bacteroides fragilis*. Although both clindamycin and metronidazole have demonstrated more activity regarding entrance into abscess cavities and ability to reduce the bacterial counts in these cavities,[44] cefoxitin was chosen to simplify therapy to a single intravenous agent and to further document the efficacy of the laparoscopic surgical procedure to successfully treat the abscess; i.e., the intravenous antibiotic alone should not be considered the reason for successful therapy.

Operative Technique

General technique and instrumentation are described in more detail in the chapter on laparoscopic treatment of ectopic pregnancy (see Chap. 5). The laparoscopic procedure is always performed under general anesthesia. A CO_2 insufflator capable of delivering CO_2 at a rate of at least 3 L/min is valuable for maintaining a pneumoperitoneum, thus compensating for the rapid loss of CO_2 during suctioning (see Chaps. 2 and 3). Hysteroscopy may be performed during peritoneal insufflation, followed with placement of a Cohen cannula in the endocervical canal. A 10-mm laparoscope is inserted through a vertical intraumbilical incision. Lower quadrant 3-mm and 5-mm puncture sites are made below the pubic hairline and just medial to the inferior epigastric vessels (Fig. 8-1).

Grasping forceps or a blunt probe, inserted through the 3-mm right-sided trocar sleeve, is used for traction and retraction. The upper abdomen is examined and the pelvis then placed in a 20° Trendelenburg position. Should the bladder be distended, a Foley catheter is inserted. A suction–irrigator–dissector (Aquapurator) or a suction probe attached to a 50-cc syringe is inserted through the 5-mm left-sided trocar

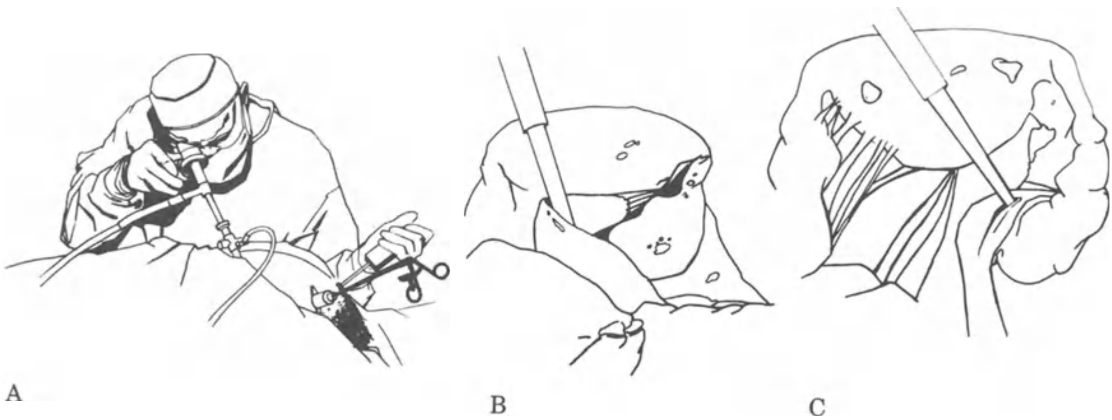

FIGURE 8-1. (A) Operative technique using laparoscope with beam splitter and two pubic hairline lower abdominal puncture sites, one with grasping forceps and the other with the Aquapurator. (B) Separation of small bowel from right tuboovarian abscess using Aquapurator. (C) Drainage and aspiration of purulent material from right tuboovarian abscess cavity.

sleeve and is used to mobilize omentum, small bowel, rectosigmoid, and tuboovarian adhesions until the abscess cavity is entered. Purulent fluid is then aspirated, with the operating room table placed in a 10° Trendelenburg position. Cultures are taken from the aspirated fluid, from inflammatory exudate excised with biopsy forceps, and from exudate near the tubal ostium obtained with a bronchoscope cytology brush (American Endoscopy, Mentor, OH: or Microvasive, Milford, MA). Following aspiration of the abscess cavity, the Aquapurator is used to completely separate the bowel and omentum from the reproductive organs and to completely lyse tuboovarian adhesions using aquadissection. Aquadissection is performed by placing the tip of the Aquapurator against the adhesive interface between bowel–adnexa, tube–ovary, or adnexa–pelvic side wall and by using both the tip of the device and the pressurized fluid flowing from it to make a dissection plane that can be extended either bluntly or with more fluid pressure. The 3-mm grasping forceps are used to exert tension on the tissue to be dissected so that the surgeon's eye at the end of the laparoscope can identify the distorted tissue plane accurately. Following completion of the dissection, the abscess cavity (necrotic inflammatory exudate) is excised in pieces using 5-mm biopsy forceps.

Following ovulation, purulent material from acute salpingitis can gain entrance to the inner ovary (inoculation of the corpus luteum at or following ovulation), which may then make up part of the abscess wall. Thus after drainage of the abscess cavity and mobilization of the ovary, a large gaping hole may be noted in the ovary where it was intimately involved in the abscess cavity. This area is well irrigated and heals spontaneously. Significant bleeding is rarely encountered.

Grasping forceps are then inserted into the fimbrial ostia and spread to free agglutinated fimbria. Retrograde irrigation is performed and the fimbrial mucosa visualized with the laparoscope to note and record mucosal quality. Tubal lavage with indigo-carmine dye through a Cohen cannula placed in the uterus is attempted for future prognostic purposes. With early acute abscesses, tubal lavage rarely demonstrates tubal patency because of interstitial tubal edema. When the abscess process has been present for longer than 1 week or the patient was previously treated with an antibiotic, tubal lavage often documents tubal patency. Rarely, inspissated necrotic material is pushed from the tube during the tubal lavage procedure.

Throughout the procedure, the peritoneal cavity is extensively irrigated with Ringer's lactate solution until the effluent is clear. The total amount of irrigant is usually more than 15 L. Ringer's lactate solution (2 L) is delivered through the Aquapurator into the upper abdomen, 1 L on each side of the falciform ligament, to dilute any purulent material that may have gained access to these areas. The reverse Trendelenburg position is then used to suction as much fluid as possible out of the peritoneal cavity. At the close of each procedure, 2 L of fresh Ringer's lactate is left in the peritoneal cavity to separate the affected tissue during the early healing phase. "Underwater" examination is performed to observe the completely separated tubes and ovaries and to document complete hemostasis. The umbilical incision is closed with 4-0 Vicryl (Ethicon, Somerville, NJ), and the 5- and 3-mm incisions in the lower quadrant are loosely approximated with collodion, allowing drainage of excess Ringer's lactate solution should increased intraabdominal pressure be present. Drains, antibiotic solutions, and heparin are not used. Second-look laparoscopy is encouraged.

The more acute the abscess, the easier the dissection. Patient and physician delay often make the laparoscopic procedure more difficult than it need be. However, even chronic abscesses are treatable with careful blunt aquadissection.

Postoperative Care

Postoperatively, the patient is usually ambulatory and placed on a diet as tolerated following recovery from anesthesia. An elevated temperature rarely persists past the second postoperative day. Intravenous cefoxitin is continued until discharge. The patient is discharged on oral doxycycline 1 day after she becomes afebrile, usually on postoperative day 2, 3, or 4. Doxycycline is continued for ten outpatient days. The patient is examined 1 week after discharge, after which all restrictions are removed.

Laparotomy Versus Laparoscopy

Most reports on the operative laparotomy technique for tuboovarian abscess emphasize that the tissues are edematous, congested, and friable, and that they tear easily; capillary and venous oozing can be profuse, and thus the degree of hemostasis achieved at the end of the procedure is often less than that usually acceptable in gynecologic surgery. Blood loss requiring transfusion is common.[30] These reports also suggest that there is no place for fine meticulous dissection and that the bowel is especially vulnerable to injury as it is separated from the pelvic viscera.

Laparoscopic lysis of adhesions using the Aquapurator is rarely bloody. Capillary oozing does occur but ceases spontaneously as the procedure progresses. Blood loss is rarely more than 100 ml. After drainage of the abscess, débridement of much of its wall, and multiple irrigations, pelvic tissue can be seen to return to some degree of normalcy before the end of the procedure. Special care is necessary when débriding purulent exudate from small bowel surfaces and when separating loops of small bowel. Usually the Aquapurator works satisfactorily, but on occasion biopsy forceps are necessary to gently tease loops of bowel apart and excise tenacious exudate.

Complications of laparotomy treatment of pelvic abscess include superficial wound infection, wound dehiscence, bowel injury including delayed perforation of bowel secondary to unrecognized injury, bowel obstruction, persistent undrained collections, thrombophlebitis, pulmonary embolism, septic shock, and subdiaphragmatic collections with pleural effusion. The subphrenic region can be well visualized and irrigated directly. Delayed bowel perforation secondary to an unrecognized injury is a rare complication of laparoscopy, especially as laser or electrosurgery is infrequently used.

Bowel injury, the most common serious operative complication of abscess surgery via laparotomy, has never been reported with a laparoscopic approach.

Special Situations

Acute Salpingitis Including Tuboovarian Complex

Laparoscopy for the successful treatment of acute salpingitis has been reported in France.[17,45] Acute salpingitis discovered at laparoscopy is easily amenable to laparoscopic treatment. Culture specimens should be obtained from exudate in the cul-de-sac and on the tube–ovary using a bronchoscope cytology brush. Using the Aquapurator, the swollen tube is gently separated from the pelvic side wall and ovary. The ovary itself is completely mobilized from the pelvic side wall. Should fibrinous exudate be present on the peritoneum of the cul-de-sac, pelvic side walls, tubes, or ovaries, it is mobilized and excised with either the tip of the Aquapurator or 5-mm biopsy forceps. Extensive irrigation of the peritoneal cavity is then performed using at least 5 L of Ringer's lactate with another 2 L left in the peritoneal cavity at the close of the procedure. As previously noted, the more acute the pelvic adhesions, the easier they are to lyse.

Ruptured Tuboovarian Abscess

In 1954 Vermeeren and TeLinde[46] reported a 90% mortality rate with ruptured tuboovarian abscess prior to 1945. This rate dropped to 12% by 1954 following an aggressive surgical approach including TAH/BSO. Immediate operation has been shown by other authors to greatly reduce mortality in this condition.[47,48] Today there is universal agreement that the approach must be surgical when a ruptured abscess is suspected. Rarely has a conservative medical or surgical approach for this life-threatening condition been reported.

Rivlin and Hunt[49,50] applied a conservative surgical approach to the treatment of 113 consecutive patients with generalized peritonitis due to ruptured tuboovarian abscess during 1972–1976. Only four hysterectomies were performed. The surgical approach was directed at removal of the septic source, evacuation of purulent and necrotic material, and abdominal drainage by continuous postoperative antibiotic peritoneal lavage. The mortality rate was 7%. Hormonal and menstrual functions were retained in 73.5%, and the potential for future pregnancy was 42.5%. Further surgery was required in 17.5% of the patients.

Today laparoscopic surgery can be considered an aggressive conservative surgical approach! Early laparoscopy for treatment of all cases of suspected pelvic abscess would virtually eliminate any possibility of a tuboovarian abscess rupturing during medical therapy. The laparoscopic techniques described previously pertain also to ruptured tuboovarian abscess. The author has treated laparoscopically one ruptured tuboovarian abscess and one diffuse feculent peritonitis secondary to a perforating sigmoid adenocarcinoma. In 1977 a woman with bilateral tuboovarian and pelvic abscesses who had been treated with cephalothin on three occasions over the previous 3 months was evaluated by the author. After 12 hours of clindamycin–ampicillin–gentamycin therapy, the abscess ruptured. A definitive laparoscopic procedure was immediately performed, including drainage of all purulent material, separation of all pelvic organs, and extensive irrigation. She has been followed for 10 years without recurrence or pelvic pain.

The perforating sigmoid adenocarcinoma occurred in a 35-year-old woman with undiagnosed hereditary familial polyposis admitted 6 months postpartum with an acute abdomen. Definitive laparoscopic surgery included drainage of all purulent material in the peritoneal cavity and excision of fibrinous exudate throughout the pelvis and from the surface of the small and large bowels. Postoperatively she did well, but her lesion proved inoperable at laparotomy 3 weeks later.

Why Does Laparoscopic Treatment Work?

Important peritoneal defense mechanisms protecting the host from invading bacteria include absorption of the microbes from the peritoneal cavity via translymphatic absorption through specialized structures of the diaphragm for distribution to systemic defense systems, phagocytosis by macrophages and polymorphonuclear leukocytes, complement effects, and fibrin trapping.[51] Fibrin trapping and sequestration of the bacterial inoculum by the omentum, intestinal distention, and tube–ovary complex act to contain the infection initially, although abscesses may eventual form. Although fibrin traps bacteria, thereby decreasing the incidence of septicemic death, thick fibrin deposits represent a barrier to in situ destruction by neutrophils, with resultant abscess formation. Once formed, abscesses inhibit the effectiveness of antibiotics and the ability of the host to resolve the infection naturally.

Ahrenholz and Simmons[52] studied the role of purified fibrin in the pathogenesis of intraperitoneal infection. Implantation of 0.5% bovine fibrin clots containing 2×10^8 *Escherichia coli* into the rat peritoneal cavity reduced the 24-hour mortality rate from 100% to 0% (compared to that seen after implantation of *E. coli* in a similar volume of saline solution). However, the 10-day mortality rate with fibrin was 90%; 100% of rats developed intraperitoneal abscesses. A control group of animals receiving sterile clots lysed them over 1–2 weeks without abscess formation. As few as 10^2 *E. coli* per fibrin clot produced abscesses, but 10^7 or more were required to produce death; without fibrin, fewer than 10^7 *E. coli* neither killed nor produced intraperitoneal infections. Both late death and abscess size with 2×10^8 *E. coli* were directly proportional to the fibrin clot size but not the concentration of fibrin in the clot. Operative débridement of the fibrin at 4 or 24 hours completely eliminated abscess formation in surviving animals. Ahrenholz and Simmons concluded that fibrin delays systemic sepsis, but the entrapped bacteria cannot be easily eliminated by normal intraperitoneal bactericidal mechanisms, and abscess formation occurs. They also concluded that radical peritoneal débridement or anticoagulation may reduce the septic complications of peritonitis; i.e., procedures that decrease fibrin deposition or facilitate fibrin removal, either enzymatically or surgically, probably further decrease the incidence of intraperitoneal abscess formation and peritonitis.

Hudspeth[53] successfully treated 92 patients with advanced generalized bacterial peritonitis by radical surgical débridement after the source of contamination had been eliminated. The ages of these patients varied from 3 to 69 years. All were critically ill, and more than 90% had mechanical intestinal obstruction. Although the operations were tedious and often prolonged (average operating time 3 hours), all patients survived, and postoperative complications were minimal. Hudspeth believed that treatment success resulted from preventing further contamination and restoring the peritoneum to a state that allows normal host defense mechanisms to clear any residual infection. He further emphasized that the obvious way of preventing residual abscess formation and allowing the peritoneum to clear intraabdominal infection is to break down all inflammatory adhesions, remove all necrotic tissue, eliminate any possible anaerobic condition, and reduce the bacterial count to a practical minimum.

Success with laparoscopic treatment further substantiates the laboratory findings of Ahrenholz and Simmons.[52] Laparoscopic drainage of a pelvic abscess followed by lysis of all peritoneal cavity adhesions and excision of necrotic inflammatory exudate allows host defenses to effectively control the infection. In addition, extensive direct peri-

TABLE 8-1. Cost differences of medical and laparoscopic treatment of tuboovarian abscess

Item	Medical management (12 days)	Laparoscopic management (1 day)
Room	$ 2,580	$ 215
Pharmacy	$ 5,151	$1,172
Radiology	$ 851	0
Laboratory	$ 1,619	$1,097
Operating room	$ 849 (50 min)	$1,627 (250 min)
Anesthesia	$ 359	$ 925
Central supply	$ 599	$ 606
Total	$12,008	$5,642

toneal cavity irrigation helps débride peritoneal surfaces, debulks the peritoneal cavity of bacteria, and facilitates bacterial absorption into the bloodstream where antibiotics are more effective. Hudspeth's[53] and this author's results confirm that there is no substitute for hard work. Meticulous dissection and attention to detail when separating adhesions and débriding necrotic purulent exudate produce results that are advantageous to the patient and rewarding for the surgeon.

Economic Considerations

Approximately 1 million women are treated for salpingitis in the United States each year at an estimated cost of more than $1 billion[54] (see Chap. 23). A 1984 national estimate of direct and indirect expenditures associated with the diagnosis and treatment of PID approached $2 billion per year.[55] Method and colleagues,[56] considering an average accuracy rate of 65% in the clinical diagnosis of PID, determined that no significant additional expense would have been incurred if all women admitted with a clinical diagnosis of PID underwent laparoscopic verification of their clinical diagnosis, compared to the cost of treatment with intravenous antibiotics for 3–5 days.

An initial conservative antimicrobial approach to management of an unruptured tuboovarian abscess often results in prolonged and repeated hospitalizations. Table 8-1 vividly demonstrates the cost differences between medical and definitive laparoscopic surgical therapy. The patient, an 18-year-old woman with a large (more than 10 cm) painful pelvic mass was treated medically for 12 days. The diagnosis of bilateral tuboovarian abscess was confirmed laparoscopically. Her total hospital charge exceeded $12,000, including a pharmacy charge of $5151, operating room charge of $849, and anesthesia charge of $395. Nine days after discharge, she was readmitted for a definitive laparoscopic procedure because of persistent pain and mass (Figs. 8-2 and 8-3). The total hospital charge for this 2-day admission was $5642, including a $1172 pharmacy fee, a $1627 operating room fee, and $925 for anesthesia. The operative proce-

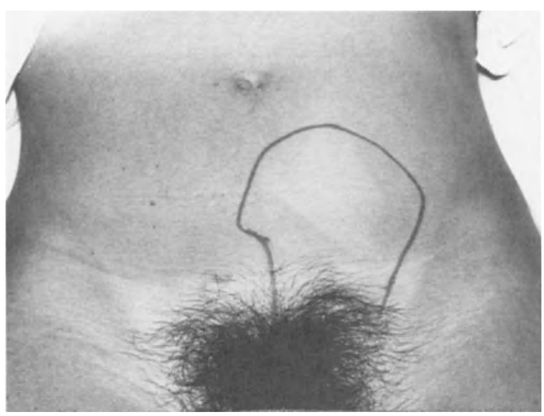

FIGURE 8-2. Outline of palpable left ovarian abscess.

FIGURE 8-3. Laparoscopic visualization of the left ovarian abscess outlined in Figure 8-2. Note the neovascularization characteristic of a long-standing abscess.

dure on the second admission lasted 4 hours because of the increased vascularity of early organizing fibrous adhesions. Had a definitive laparoscopic procedure been performed on the first admission, the dissection would have been far simpler and the total cost decreased by more than 200%.

Conclusion

The goals of managing acute tuboovarian abscess are prevention of infertility and the chronic residuals of infection including pelvic adhesions, hydrosalpinx, and pelvic pain, each of which may lead to further surgical intervention. Laparoscopic treatment is effective and economical. It offers the gynecologist 100% accuracy of diagnosis, including the extent of tuboovarian involvement, while simultaneously accomplishing definitive treatment with a low complication rate. This approach allows tuboovarian conservation with subsequent fertility potential. Additionally, laparoscopy has a high degree of patient acceptance due to minimal incision, shorter hospital stay, and early return to full activity. The combination of laparoscopic treatment and effective intravenous antibiotics is a reasonable approach to the treatment of the total spectrum of PID, from acute salpingitis to ruptured tuboovarian abscess, with many inherent benefits including complete resolution of the disease process without sequelae.

Whether the combination of laparoscopic surgery and antibiotics will ultimately prove superior to antibiotics alone for prevention of chronic pelvic adhesions including hydrosalpinx is a question that should be resolved through multiinstitutional controlled studies using second-look laparoscopy. Early experience with laparoscopic treatment of pelvic abscess combined with intravenous antibiotic therapy is promising and may achieve better results than early surgery or medical treatment alone.

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9 Myomectomy

RONALD L. LEVINE

Pelviscopic surgery is used for a wide range of applications, as other chapters have illustrated. One such procedure that is especially challenging is myomectomy. However, the surgeon must be able to demonstrate that it is a fruitful choice and more than just technical gymnastics.

It is now well known that uterine leiomyomas are almost ubiquitous, occurring in one of every four to five women of premenopausal age. Although there are many theories, a review of the literature would indicate that there is still a great deal that is unknown regarding their etiology.[1] Leiomyomas arise from a single neoplastic cell derived from the smooth muscle elements of arterioles as well as directly from the myometrium. Their growth is apparently influenced by various factors including increased estrogen.

An estimated 20–25% of leiomyomas produce symptoms, the severity of which are primarily dependent on the size and location of the tumors. In Buttram and Reiter's review,[2] 30% of myomectomy cases revealed preoperative complaints of menstrual abnormalities. The authors' explanation of the role of myomas as the cause of these abnormalities provides a plausible account not only for the bleeding problems but also for leiomyoma-associated infertility. Myomas have a small but significant role in infertility. The Buttram–Reiter theory is based on the studies of Farrer-Brown and associates,[3,4] who demonstrated that uterine bleeding associated with leiomyomas results from compression of venous plexi of the adjacent myometrium and endometrium. Their study provided radiographic evidence whereby not only submucous or intramural myomas, but also subserous tumors may cause congestion and dilatation of the subjacent endometrial venous plexi. The mechanism responsible for this action is initiated by the enlarging tumor impinging on the veins of the inner myometrium or on the arcuate and radial veins, which course throughout the intramural and subserosal regions of the myometrium. The obstruction caused by the tumors produce venule ectasia, which probably plays an important role in the production of abnormal uterine bleeding (Figs. 9-1 and 9-2).

Although abnormal menstrual bleeding and possible infertility alone are adequate reasons for myomectomy, there are other indications. Pedunculated myomas may twist, resulting in infarction and pain as well as creating problems in the differentiation of myomas from adnexal neoplasms. Pedunculated myomas are particularly suited for removal by pelviscopic myomectomy. These previous explanations emphasize that there is a role for the pelviscopic removal of pedunculated myomas and hysteroscopic submucous resections, as well as excision of subserosal tumors by the pelviscopic approach.

Berkeley et al.[5] reviewed myomectomies performed at Yale–New Haven Hospital from 1976 to 1977 and concluded there was a

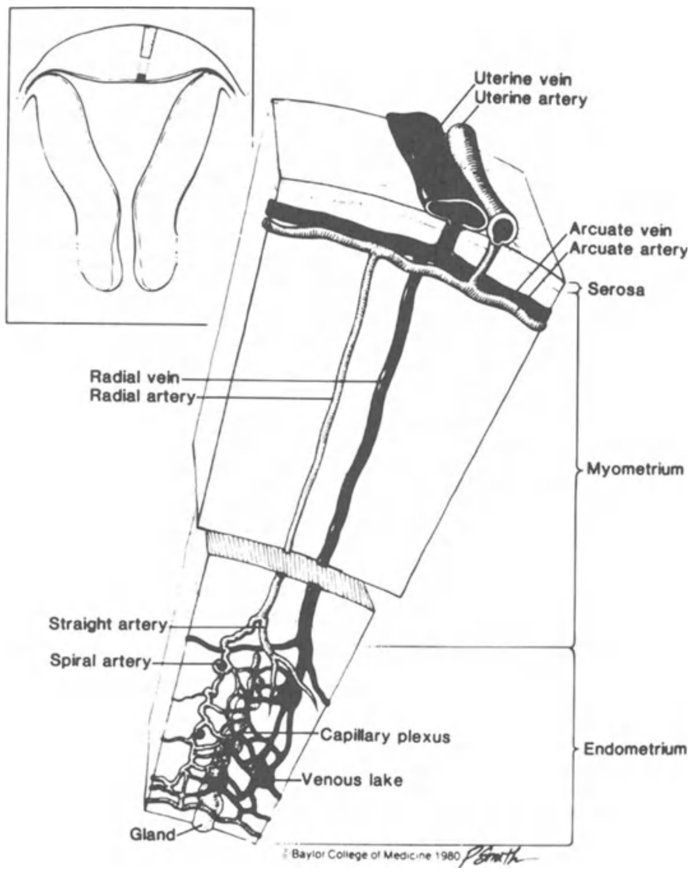

FIGURE 9-1. Normal uterus. Section through a normal uterine wall illustrating normal vessel anatomy. (From Buttram VC Jr, Reiter RC: Uterine leiomyomata: etiology, symptomatology and management. Fertil Steril 1981;36:433. Reproduced with permission of the publisher, The American Fertility Society.)

decrease in fertility that was probably secondary to adhesion formation following myomectomy surgery. Pelviscopic surgery has been credited with a decreased incidence of adhesions.[6,7] Therefore if a myoma is amenable to the pelviscopic approach and myomectomy is indicated, pelviscopic myomectomy may be the treatment of choice.

Though sarcomatous changes are rare, with an estimated incidence of 1/1000 or lower, some risk is present. However, the performance of myomectomy, whether by open laparotomy or by laparoscopic surgery, entails the same risk factors.

Indications for removal of subserosal myomas include size larger than 2 cm plus one of the following.

1. Symptoms such as recurrent bleeding with negative hysteroscopic examination
2. Obstruction of a fallopian tube as demonstrated by hysterosalpingogram, chromotubation, or both
3. Recurrent early fetal wastage or infertility with no other explanation

The removal of "small" subserosal myomas probably has no advantages unless one feels so strongly about "big trees from little acorns grow" that the end justifies the means, i.e., energy expended. One would not operate solely for a small myoma, but if surgery had been executed for removal of a large mass such small tumors could be removed at the same time.

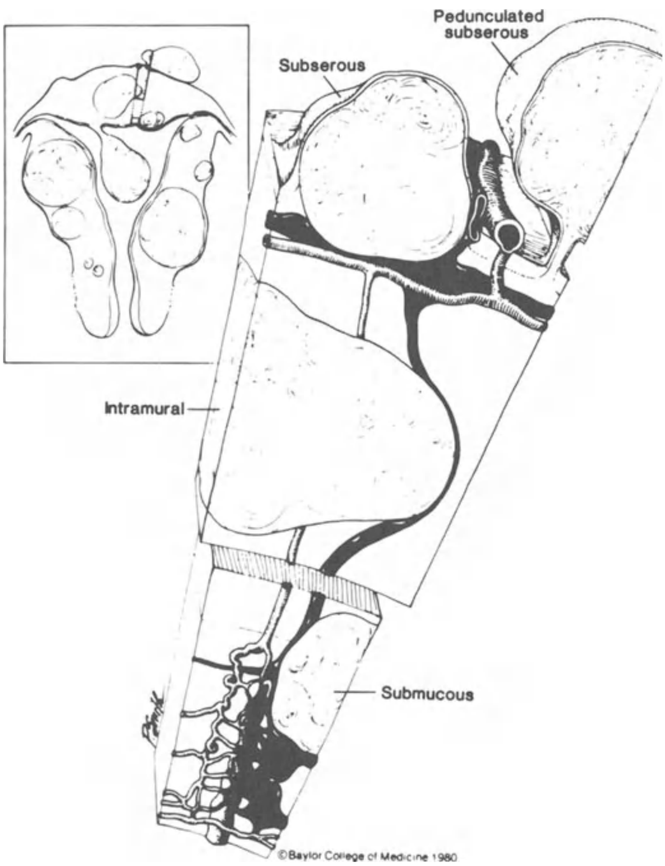

FIGURE 9-2. Myomatous uterus. Section through myomatous uterine wall illustrating vessel obstruction leading to venule ectasia. (From Buttram VC Jr, Reiter RC: Uterine leiomyomata: etiology, symptomatology and management. Fertil Steril 1981;36:433. Reproduced with permission of the publisher, The American Fertility Society.)

Procedure

Pedunculated Leiomyomas

Semm has reported on techniques of pelviscopic myomectomy, particularly involving pedunculated myomas.[8–10] There are several methods by which the pedunculated tumors may be removed.

As for all cases of pelviscopic surgery, a high-flow insufflator is of utmost importance because of the frequent instrument changes. The author uses a four-puncture technique: the laparoscope plus three 5-mm punctures in the lower abdominal wall. The blood supply to the myoma must first be controlled—usually a relatively simple task for pedunculated tumors. Hemostasis may be secured by one of several techniques. The coagulation technique can be accomplished with either an endocoagulator using alligator forceps or a bipolar coagulator using Kleppinger forceps. If coagulation is used, the stalk is coagulated close to the uterus. The stalk can then be severed with standard hook scissors. An alternative method of hemostasis is use of the loop ligature. The Endoloop (Ethicon, Somerville, NJ) ligature is loaded in an applicator that is then placed through a 5-mm sleeve, as described in Chapter 2. One- or two-loop ligatures are used depending on the thickness of the stalk (Fig. 9-3). The ligature

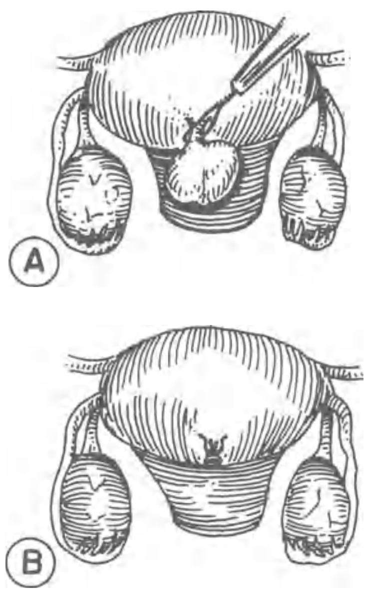

FIGURE 9-3. (A) Loop ligature is placed around the pedicle of a pedunculated myoma. (B) Myoma has been cut free distal to the ligatures.

is placed close to the uterus, being careful to leave a small pedicle so the ligature does not slip off when the stalk is cut. The tumor is then removed as described later in this chapter.

Subserosal Myomas

Subserosal myomas are more difficult to excise. It is left to the discretion and skill of the operator as to which tumors are amenable to the pelviscopic approach. Tumors that are anterior and superiorly placed are best suited for pelviscopic surgery. The size of the tumor is also a factor when determining the advantages or disadvantages of pelviscopic surgery. Tumors on the posterior surface are more difficult to expose and remove. Tumors that are intraligamentous are not amenable to pelviscopic surgery. Myomas as large as 8–9 cm have been removed, the limiting factor usually being the ability to remove the tumor from the abdomen.

When all the sleeves are in place as described previously, a needle is passed and the serosa overlying the myoma is injected with a dilute (1:100 ml normal saline) vasopressin (Pitressin; Parke Davis, Morris Plains, NJ) solution (Fig. 9-4). The reader is referred to Chapter 5 for use of vasopressin. A long needle on the end of a 5-mm tube may be used, but these needles are usually of large caliber. Unless the patient is very obese, a long, 22-gauge spinal needle can be placed directly through the abdominal wall and the site injected. The author has also used this technique for injecting an ectopic pregnancy (see Chap. 5). An incision is made with hook scissors along this injected line. A laser or a unipolar needle electrode may be used to make this incision in a hemostatic manner. The middle 5-mm site is used to insert a myoma enucleator. This instrument has a sharp end that can be heated to a desired temperature (100–110°C) (Fig. 9-5). The edges of the serosa are held apart by toothed biopsy forceps as the endocoagulating knife is used to separate the tumor from the surrounding tissue. Large grasping forceps can be used to exert traction in a twisting fashion. As the knife slides back and forth, the tumor is slowly freed from its bed, usually with little bleeding. When the tumor is free, it is left in the cul-de-sac until the surgeon is ready to remove it.

If there is any bleeding from the fossa, it can usually be controlled with a point coagulator or the flat part of the myoma enucleator. If the operator has laser capability, the CO_2 laser can be used in the defocused mode to vaporize and coagulate the base. If the defect is large, sutures can be placed in the defect via one of several methods. Endosutures, though not readily available on the American market, may be used. The Endosuture is chromic catgut with a small, straight needle swaged on one end. The other end goes through a plastic guide, as with an Endoloop. The suturing is performed using 3-mm and 5-mm needle holders. The end is brought out through the applicator, and an external knot is made and slipped back down with the plastic guide. Al-

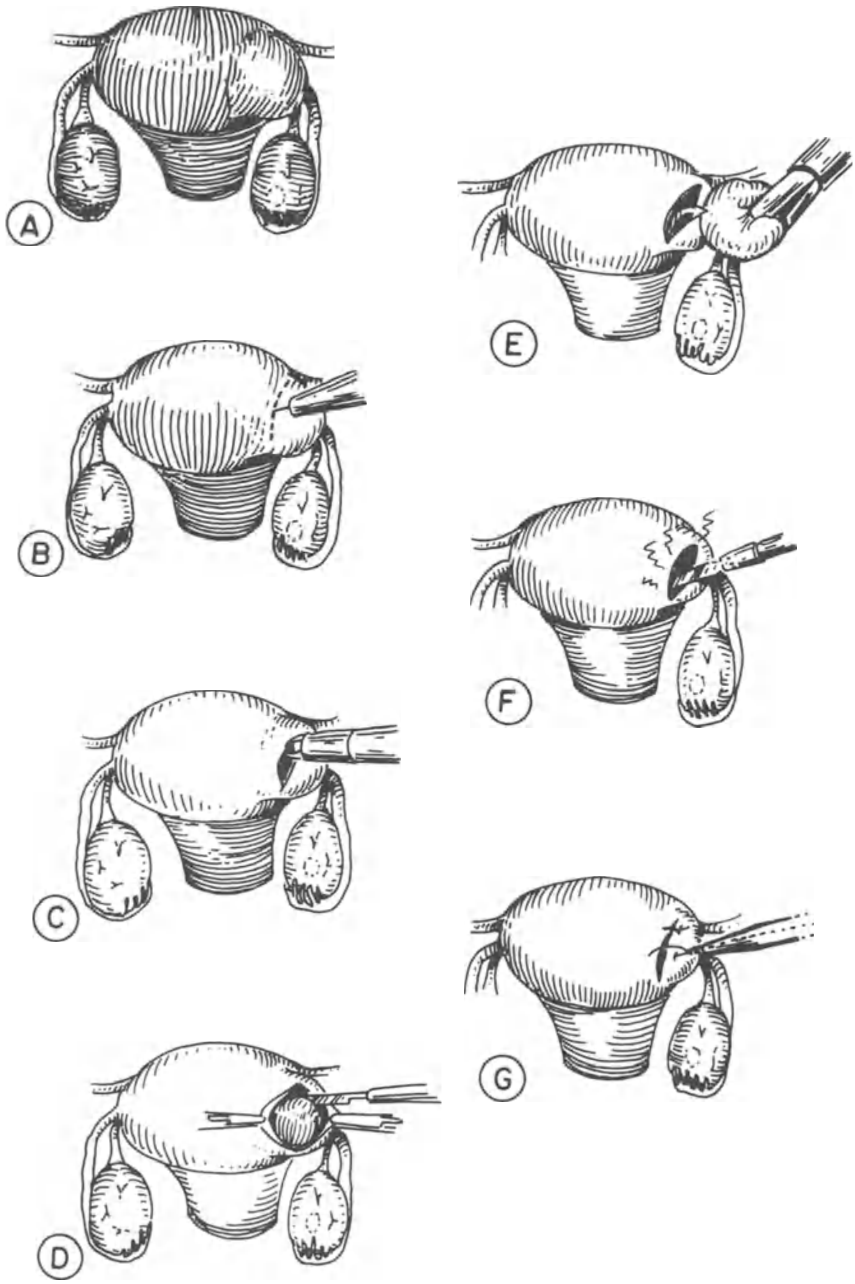

FIGURE 9-4. (A) Myoma near the right cornua. (B) Injection is made over the myoma with vasopressin. (C) Incision is made over the injected area. (D) Serosal edges are held apart, and the myoma enucleator slides back and forth. (E) Traction is exerted on the tumor with a twisting motion. (F) Base is coagulated. (G) Serosal edges are sutured, if gaping, to ensure hemostasis.

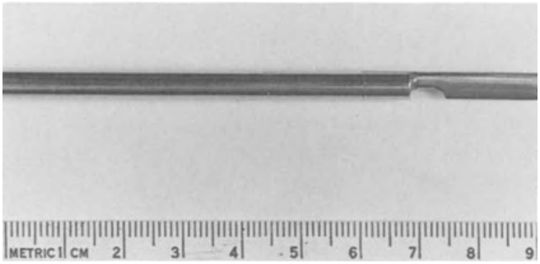

FIGURE 9-5. End of the myoma enucleator. The edge is sharp and can be heated to 100°C. It is then used to separate the tumor from the surrounding tissue.

ternatively, one may use a suture material, e.g., PDS (Ethicon) with a swaged-on needle, to make an intraabdominal knot (Fig. 9-4).

Removal of Extirpated Tissue

The myomas that are left in the cul-de-sac after closing the capsule and irrigating with either normal saline or Ringer's lactate solution can then be removed. Removal may be performed with a morcellator (see Chap. 2) passed through an 11-mm sheath. This approach is the optimal if the myoma is small and not well calcified. However, if the tumor is large, use of the morcellator is difficult. The tumor sometimes can be cut in a piecemeal fashion using hook scissors for removal in pieces through an 11-mm sheath. Alternative methods include use of the CO_2 laser to morcellate the myomas or vaporize the tumor mass, a prolonged, tedious procedure.

A useful means of tissue removal of myomas, as well as ovarian cysts, is the colpotomy incision. Dermoids also may be removed by this technique without capsule rupture. After the mass has been cut free and all suturing and hemostasis is completed, a colpotomy incision is made in the posterior cul-de-sac. It can be performed transvaginally, or initiated laparoscopically using the assistant's fingers in the cul-de-sac. Hook scissors can incise the tissue through the peritoneum and vaginal mucosa. After a finger is pushed through it, the opening may be dilated using a large clamp such as uterine packing forceps. The pneumoperitoneum is rapidly lost, so the tumor must be in a position that is ready to be grasped from below with either tumor forceps or a large Allis clamp. Once the tissue is brought tightly against the colpotomy incision, the high-flow insufflator rapidly reinsufflates the abdomen. With traction from below and pushing from above, fairly large tumors can be removed. The colpotomy is easily closed from the vagina; however, if any oozing is noted through the laparoscope this area can be sutured from above.

The pelvis is finally irrigated with copious amounts of Ringer's lactate solution using an Aquapurator (WISAP, Sauerlach, West Germany) or similar irrigation device. The patient may be sent home as an outpatient if the tumor is pedunculated or the myoma is small. However, if the myoma is large and a substantial raw bed is present as a possible bleeding source, these patients are best observed for 24 hours.

Caution and discretion are the key words with this surgery. If at any time the operator does not feel in control of the surgery or if bleeding becomes a problem, laparotomy should be considered immediately. All patients are informed preoperatively that laparotomy is a strong possibility and therefore are prepared for either approach. If the pelviscopic myomectomy is successful, however, the benefits that accrue, e.g., decreased morbidity, hospitalization, and cost as well as rapid return to the work place, are gratifying to both the patient and surgeon.

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10
Tubal Reconstructive Surgery

JOHN M. LEVENTHAL

> It is better to know some of the questions than all of the answers.
>
> JAMES THURBER

The restoration of tubal patency and function has long been solely the province of open reconstructive surgery. With the introduction of electronically controlled insufflators and innovative instrumentation, as well as the steady increase in laparoscopists trained in the procedures of pelviscopic reconstructive surgery, successful repair of the fallopian tube has become part of the repertoire of advanced operative laparoscopy. There seems little question that open surgery, whether microscopic or macroscopic, carries with it a significantly greater risk of postoperative adhesion formation than does the closed pelviscopic technique. For this reason alone, pelviscopic surgery is preferred, when possible, for the woman with impaired infertility. However, as has been amply stated elsewhere, morbidity, short hospital stay, and cost-effectiveness are also valid arguments for the closed approach (see Chap. 22). If the ultimate results, in terms of intrauterine pregnancy, are comparable, it may well be that the pelviscopic approach is to be preferred in any case. In this chapter, we will describe the indications and technique of pelviscopic neosalpingostomy and discuss results. Experience, judgment, level of skill, and personal preference are all valid factors when considering any surgical procedure. The pelviscopic approach to terminal neosalpingostomy as a viable alternative to microsurgical or macrosurgical laparotomy will be presented. We will attempt to convey the very subjective sense of when it is advisable to abandon surgical repair in favor of in-vitro fertilization and embryo transfer (IVF-ET).

As will become abundantly clear, it is not always possible to use the pelviscopic approach in all cases of reconstruction. The well-trained and prudent pelviscopic surgeon will evaluate the pelvic findings on initial laparoscopic view and make a decision for either an open or closed technique based on those observations. There must be no opprobrium attached to the abandonment of pelviscopic surgery when its employment would constitute an unnecessary risk to the well-being of the patient or would carry a prognosis for pregnancy so bleak as to make the procedure merely a "tour de force." In the latter instance, the severity of the pelvic adhesions and tubal damage should dictate IVF-ET, and all surgical restorative efforts are directed only to clearing the ovaries for ovum retrieval. It should not be necessary to emphasize that the possibility of open surgery, or even the abandonment of surgery, should be made clear to the patient before the procedure. Written confirmation of that understanding should be in the patient's chart.

Preoperative Indications

The object of pelvic reconstructive surgery in the infertile woman in general, and in the case of neosalpingostomy in particular, is to restore the normal interanatomic relationships of the pelvis and the patency of the fallopian tubes by means that carry with them the best chance for success (a term pregnancy), the least risk of postoperative adhesion formation, and the safety of the patient. The medical or surgical indications for pelviscopic neosalpingostomy are really no different than those for open surgery. Although one can never say "never" when speaking of medical prognoses, the chances of conception in the woman with closed tubes is at best close to zero. Repair and reestablishment of position and patency, therefore, is preeminent in the treatment of infertility.

As is usually accepted, the mechanism for the distal closure of the fallopian tubes involves in every case an inflammatory reaction (usually infectious) of the endosalpinx—of at least the distal ampulla and probably the entire tube. With the inflammatory exudate produced at the time of the acute episode, fibrinous adhesions are formed between the tubal fimbriae and between the distal endosalpingeal walls, causing apposition of these structures and eventually closure of the tubal ostium. In the normal course of the healing process, the replacement of fibrin with collagen results in the deposition of scar tissue, fusing and sometimes destruction of fimbriae, and finally complete distal occlusion of the tube and the formation of the typical hydrosalpinx. The process is virtually always bilateral, although the end-stage damage may vary considerably from tube to tube (see Chap. 7).

For the pelviscopic surgeon specializing in infertility, the diagnosis of tubal occlusion will often have been made by the referring physician either at diagnostic laparoscopy or by previous hysterosalpingogram. However, if not, and the diagnosis is suspected from the patient's history of previous pelvic infection and inability to conceive, it is appropriate to make the determination of closure or patency at the time of the planned pelviscopic procedure. It is certainly *not* necessary, in such a case, to perform diagnostic laparoscopy first. Traditional practice to the contrary notwithstanding, in most cases it may not be especially helpful to obtain a radiograph of the tubes and uterus before proceeding with the definitive operation.

Intraoperative Indications

In many cases the decision to proceed with tubal repair by pelviscopic surgery or by open surgery must await the initial laparoscopic findings at the time of the definitive procedure. Frequently the tube not only is closed at its distal end but is also adherent to itself, the ovary, and often the pelvic sidewall as well. The degree of this adhesion formation, and particularly the location in the pelvis of the end of the tube, will determine the possibility of using the closed approach for tubal reconstruction. These factors form the basis for the final indication or contraindication to pelviscopic surgery. When the end of the tube is completely buried in dense fibrous adhesions deep in the cul-de-sac, it may not be possible to free it sufficiently for terminal salpingostomy without significantly damaging the integrity of the tubal serosa and possibly even the continuity of the tube. If this situation pertains, there should be no hesitation on the part of the surgeon in turning to laparotomy and microsurgery to accomplish the surgical objective or to abandon reconstruction in favor of referral for IVF-ET. The experience of the surgeon will of course be a factor in this decision, which again underscores the importance of sufficient training.

Other intraoperative factors occasionally influence the decision for or against pelviscopic surgery. The presence of extensive endometriosis, with or without endometrioma formation, may so distort the anatomy of the pelvic sidewalls that reconstructive procedures conducted in the closed environment of pelviscopic surgery may pose a significant threat to such vital structures as the ureter or iliac vessels. Such distortion is common with the extensive scarring seen in widespread endometriosis and may well be sufficient to contraindicate the closed approach. Although leiomyomas may have little influence on conception per se, in some cases the distortion of the uterus may be sufficient to make safe access to the distal portion of each tube impossible during pelviscopic surgery. In such a contingency, it is sometimes necessary to remove the fibroid(s) in order to reach the tube. However, if they are not subserous in location, pelviscopic removal of fibroids may not be advisable, and open surgery would then be indicated (see Chap. 9).

Instrumentation

As has been emphasized in earlier chapters, the success of any pelviscopic procedure is greatly dependent upon the availability, in good working order, of all pelviscopic instruments appropriate to the operation at hand. Certainly pelviscopic neosalpingostomy is no exception. For this particular procedure the right instruments must be available for at least four essential tasks: (1) lysis and resection of adhesions; (2) identification and opening of the distal tube; (3) eversion of the newly created stoma; and (4) chromopertubation and thorough saline lavage of the pelvis. These steps will be reviewed in detail in the succeeding discussion. The importance of constant regular preventive maintenance and routine inspection and replacement of pelviscopic instruments cannot be overemphasized. For example, cutting instruments such as scissors and cautery knives must be kept sharp and should be available in duplicate or triplicate for any case. Thorough familiarity with the assembly and use of *every instrument available* by motivated ancillary personnel is not only desirable but essential for the smooth conduct and success of this often complex procedure (see Chap. 2).

It is no longer possible to speak of pelviscopic surgery instrumentation without mentioning the medical laser. Although discussed in detail elsewhere in this volume, it should be noted that the employment of laser technology has added significantly to the whole range of reproductive surgery in general and to pelviscopic surgery in particular. Steady refinement of the CO_2 laser has expanded its use in laparoscopy. More recently, the development of the argon and Nd:YAG laser with their capabilities of being transmitted through flexible fibers has opened up entirely new possibilities for pelviscopic surgery.[1]

Technique

Table positioning, anesthesia, and initiation of the laparoscopic portion of the procedure are no different from that described earlier (see Chap. 3). However, to maintain a clear operative field, with the bowel well up out of the pelvis and over the pelvic brim, it may be necessary to utilize a rather steep Trendelenburg position. Therefore, well-padded shoulder braces should be considered to keep the patient in position, as previously described in Chapter 2. The anesthesiologist is in the best position for observation and should monitor the placement of the braces periodically to make sure they have not slipped.

After making a comprehensive survey of the pelvis and operative field, the first corrective efforts of the pelviscopic surgeon should be directed to reestablishment of the normal interanatomic relationships of the pelvic viscera. It is therefore important to understand these relationships as they exist at the commencement of the procedure. Thick, well established adhesions involving the large and/or small bowel, omentum, ovaries, uterus, tubes, and broad ligaments completely distort the normal anatomy. In many instances, at the beginning of the case, parts of the viscera (usually the ovaries) may not be visible behind postinfectious or postoperative adhesions.

Lysis and Resection of Adhesions

As a general rule, it is advisable to start lysis of adhesions in either of the adnexal areas, starting as far cephalad as necessary and working down into the cul-de-sac and ovarian fossae. Initial attention should be paid to bowel adhesions with every attempt made to identify a line of cleavage between the bowel and the adherent organ. Division and resection of such adhesions can be made with the laser sharply focused on low-power wattage, a unipolar cutting knife on a current setting just capable of cutting the adhesion, or the unipolar pelviscopic scissors. In any case, division of adhesions involving bowel should favor the side *away* from the bowel to avoid inadvertent perforation. With thick adhesions, progress should be careful and deliberate. Adhesions that clearly contain (or are thought to contain) blood vessels should be coagulated before division using the thermal coagulating forceps if possible, bipolar electrocautery, or a unipolar electrocautery probe. Every tissue and/or adhesion should be identified with absolute certainty before coagulation or division. Where possible, adhesions should be separated from their attachments on both sides and removed from the peritoneal cavity entirely. As an area becomes free of adhesions, a thorough inspection of the viscera and serosa should be made and, if equipment is available, recorded on film or videotape. Should areas or discrete implants of endometriosis be encountered, a biopsy for histologic confirmation should be obtained and the area destroyed by laser or coagulation. Ovarian endometriomas should be aspirated and removed at pelviscopic surgery as part of the pelvic preparation for tubal repair (see Chaps. 6 and 17).

Once lysis and resection of adhesions have been accomplished and the normal relationships of the pelvic organs reestablished, the fallopian tube should possess nearly its normal mobility with respect to the cortical surface of the ovary. This mobility, which also allows the tube to be brought up into a position to permit surgical manipulation, is critical to the successful continuation of the procedure and to both the immediate and long-term success of the operation.

Identification and Opening of the Distal Tube

Three secondary puncture sites are usually necessary to ensure positive control of the tube while establishing the salpingostomy, although the exact number of such sites should be governed by the requirements of the individual case. We have found that the best compromise between the cosmetic and useful placement of these incisions is to make them along a line about 1 cm below the pubic hairline. The first incision is always placed in the midline and the others 3 to 4 cm on either side or as needed. Although cosmetic considerations are important, the surgeon should not hesitate to place another puncture site wherever the case dictates. Each secondary puncture should be accomplished under direct vision of the laparoscope to avoid injury to internal structures.

The mobilized tube is grasped with two atraumatic forceps set 180° apart, at points just below the closed distal end and brought up out of the cul-de-sac into clear vision. Dye contrast medium (indigo/carmine) diluted with saline should be instilled transcervically at this point in the procedure to distend the tube and thus help identify the details of the distal closure. The blue dye can easily be visualized through the distended tube, sometimes delineating lines of scarring. Contrary to some observations, we have found that the cicatricial lines of closure are not always evident or that adhesion formation has made these potential lines of incision difficult to identify clearly. In this case, hemostasis will have to be obtained by coagulation of the tube at the proposed incision site using either a thermal or high frequency electronic source or defocused laser. Depending on the conditions present, coagulation can proceed in a single path over the sealed end of the tube or in a stellate fashion following lines of scarring. Care must be exercised to avoid destruction of any healthy-appearing fimbriae that may be present. The incision line(s) should run next to these structures *but not through them.* A "flailing" effect should also be avoided, as the tubal "flaps" created by too many radial incisions will not allow lasting eversion and will be more likely to recoalesce postoperatively causing early reclosure of the tube.

The incision in the tube can be made by laser, unipolar knife, or unipolar scissors depending upon the situation. Despite vociferous advocacy for one method or another, there is usually little difference between any of these modalities in terms of ultimate success. Each may have an advantage in any particular case. The laser usually has the advantage of causing less damage to the fimbriae folded into the sealed-off ampulla. However, if the laser is applied longer than absolutely necessary to open the tube, it may result in destruction of the underlying endosalpinx. If the unipolar knife is used, it should be sharp enough to be tried first without current through the previously coagulated area. If it is necessary to apply current, the cutting power level should be set at the minimum necessary for crisp passage through the tissue with minimal thermal damage to the adjacent areas. Scissors are generally more useful in enlarging the opening than creating it. However, when the scarring is extensive and the tissue closing the tube is thick, unipolar scissors with small serrations placed at a right angle to the steadying forceps can sometimes accomplish the best opening.

The initial entry into the tubal lumen is begun centrally and conducted in a radial fashion along either a line of scarring or the previously devascularized area, again avoiding "flailing" of the tube. It is important to keep the tube slightly distended with pressure from the instilled dye so that when the opening is made there will be a tendency for any sealed-in fimbriae to evert with the outrushing fluid. It is important to remember that there is a direct correlation between the number of fimbriae present and the subsequent pregnancy rate. The surgeon's prognosis is often based almost solely on this finding. It is therefore vital that every effort be made to preserve healthy fimbriae when present. If any bleeding occurs, it should be treated immediately with either discrete point coagulation or control with bipolar forceps. Once open, the tubal ostium is enlarged, along scar lines if possible, to a size that will allow eversion of the mucosa and the free flow of dye. It is good practice upon opening the tube to obtain a specimen of the tubal contents for culture, making certain that bacteriologic studies anticipate *Chlamydia* and *Mycoplasma* as well as more conventional bacteria.

Although it is not essential to the success of the procedure, the visual documentation (on film or videotape) of the condition of the distal tube, both before and after salpingostomy, is often helpful in the ongoing care of the patient and in helping her understand the extent of her problem and its prognosis (see Chap. 11).

Eversion of the Newly Created Stoma

To maintain patency of the salpingostomy, it is important to establish some degree of eversion of the distal tube. In our experience, in approximately one in eight cases, opening of the tube is followed by an efflux of fimbriae and natural "eversion" of the stoma. It is the most desirable situation and the one associated with the highest pregnancy success rate. However, it will usually be necessary to "create" eversion of the tube using one or more of several techniques to be discussed. Each case is different and the prevailing conditions, as well as the equipment available, will often dictate the method used. In general, any technique that everts the newly created stoma in a manner that promotes continued patency and makes the endosalpinx and residual fimbriae available for ovum pickup is appropriate. Any one or a combination of the following techniques are capable of accomplishing these objectives: (1) serosal coagulation with defocused laser; (2) serosal coagulation with thermal or electrocautery; (3) creation of a sutured or clipped "cuff"; and (4) eversion rolling of the tube.

If the laser is available, eversion can be accomplished by encircling, with a defocused beam, the serosa of the open tube approximately 0.5–1.0 cm proximal to the opening. As the serosal surface is lightly coagulated by the laser, it contracts and pulls the everted edges of the opening outward. The same effect can be accomplished with either thermal or electrocoagulation applied in a similar fashion; we have found this technique to be as effective as laser coagulation. Suturing back the stomal edges to the serosa in a "cuff" fashion is the time-honored way of maintaining patency. Although more time-consuming and requiring experience, it can be accomplished with pelviscopic procedures using endosutures of fine material. Newly developed absorbable clips may eliminate the need for sutures for holding back the edges of the cuff. Kosasa (personal communication) has described an entirely different method of eversion with promising results. Although the method is used only at open microsurgery, it involves grasping the cut edge of the stoma with the side of the atraumatic forceps and slowly rolling the edge outward and down along the tube in a proximal direction. The procedure is repeated on four sides of the tube if possible. We have applied the Kosasa technique to pelviscopic surgery and are enthusiastic about its ease of performance in certain cases, although no long-term results with respect to patency are yet available. The eversion appears to remain in place after removal of the instrument and involves less destruction to the serosal surface than the coagulation methods.

Chromopertubation and Saline Lavage of the Pelvis

When neosalpingostomy has been completed bilaterally, the reconstruction should be evaluated and the results recorded. In order to observe the newly created tubal ostia in a manner that permits the evaluation of fimbrial salvage, it is helpful to fill the pelvis with normal saline until each tube is literally floating. Any fimbriae that are present will be suspended freely. Visualization is better without the gravitational influence. With each tube floating in the saline, dilute methylene blue or indigo/carmine dye should be instilled transcervically in a pulsatile fashion and its appearance at the distal tube closely observed. The efflux of dye should be at the *end* of the tube, and there should be sufficient mobility of the ampulla to make it available to the cortical surface of the ovary during ovulation. There should be no tendency for the sides of the stoma to fall together, although if fimbriae are present they often appear to "flow" together over the ostium.

Normal saline in quantities of 2 to 5 L is used to thoroughly lavage the entire pelvis, making sure that the aspirate is clear and that no bleeding occurs. The Trendelenburg angle should be reduced to about 5° so that any fluid in the upper abdomen has a chance to drain down into the pelvis for aspiration.

As a final step in the operation, 100 ml of dextran 70, 32% in dextrose (Hyskon; Pharmacia Laboratory, Piscataway, NJ) is placed in the pelvis through one of the secondary puncture site cannulas to decrease the incidence of postoperative adhesion formation.

Ancillary and Postoperative Care

It is probably prudent to administer a broad-spectrum antibiotic during the operation just before making an incision in the tube and to continue the prophylaxis postoperatively. Adjustment in the antibiotic used should be made in accordance with the results of the intraoperative tubal cultures. If the cultures are positive for bacterial growth, the patient's sexual partner must be treated as well.

In most institutions, pelviscopic surgery is performed in an outpatient surgical setting. With early ambulation, most patients are ready for discharge on the evening of surgery. However, with late-starting or very extensive procedures, an overnight stay in the hospital is beneficial and more considerate of the patient's safety. With more prolonged pneumoperitoneum than is usual with diagnostic laparoscopy, there is a slight increase in the incidence of substernal and shoulder discomfort from diaphragmatic irritation and abdominal distention. It can be minimized by making sure the patient remains in some degree of Trendelenburg position *after* the gas has been evacuated through the cannulas, and while the abdominal sutures are being placed. This short time allows the remainder of the CO_2 or N_2O to be absorbed and lessens the trapping of gas up under the diaphragm.

Long-Term Follow-up

Second-look laparoscopy remains the most informative method of assessing patency of the tubes in the patient who remains unable to achieve pregnancy. Indeed, it is an important enough adjunct to the salpingostomy itself to include its possibility in the original discussions of treatment with the patient. When is the ideal time to perform the second look? There are almost as many "convincing" answers as there are infertility surgeons. The argument that early intervention may allow simple lysis of thin avascular adhesions is no more valid than the argument for waiting long enough for the statistics to make pregnancy likely. There is evidence on both sides of the question. Russell and co-workers[2] at Yale have suggested that late ciliogenesis and intrinsic tubal self-repair may be thè reasons for a higher pregnancy rate in their patients who were evaluated after 5–7 years, compared with those seen after 1–2 years. Interestingly, they did *not* advocate waiting that long for laparoscopic assessment. Most infertility surgeons, including this author, tend to favor earlier rather than later intervention. Perhaps it would be appropriate to suggest that if all other fertility factors are equal and the problem seems most likely to be due to a tubal factor, second-look laparoscopy should be performed between 6 and 18 months post-salpingostomy. The older patient and the patient in whom extensive repair is necessary should dictate an earlier date.

Postoperative hydropertubation, like tonsillectomy and breast feeding, seems to swing between popularity and condemnation. Because the procedure is blind and its evaluation dependent upon such intangibles as back-flow pressure and auscultated noises, we can never know with certainty whether the tubes are open, phimotic, or closed. Nonetheless, the procedure is simple and, from the theoretic standpoint at least, capable of clearing thin filmy adhesions blocking the distal ampulla. Unless there is evidence of active infection, it appears that no harm is done. For all its subjectivity, postoperative hydropertubation is probably a reasonably valid method for the assessment of patency alone. However, if performed, hydropertubation should be done in the proliferative phase of the menstrual cycle.

Results

We have found that the pelviscopic approach to neosalpingostomy is as effective, in terms of patency and ongoing intrauterine pregnancy, as the open microsurgical methods described by others in the United States and Europe.[2–4] Table 10-1 summarizes our own modest experience and compares the two approaches. The overall pregnancy rate is essentially the same for the open microsurgical and pelviscopic methods. It is probably less method-sensitive than it is dependent upon the presence or absence of viable fimbriae. It is believed that the ectopic rate of only 8% is probably low and reflects merely an inadequate number of cases rather than the expected value. Although we did not classify the extent of tubal disease as suggested by the International Federation of Fertility Societies classification or the simple scheme proposed by Mage,[5] our 43 cases

TABLE 10-1. Neosalpingostomy

Parameter	Patent (microsurgery) (No.)	Occluded (pelviscopic surgery) (No.)
Cases		
Bilateral	24	39
Unilateral	1	4
Total	25	43
Patency (at least one tube open by laparoscopy or HSG, 2–49 months)	18/25 (72%)	39/43 (91%)
Pregnancy		
Overall	7/25 (28%)	13/43 (30%)
Spontaneous abortion	1/7 (14%)	2/13 (15%)
Tubal ectopic pregnancy	2/7 (28%)	1/13 (8%)
Term intrauterine pregnancy	4/7 (58%)	10/13 (77%)

encompassed a wide range of severity and compared favorably with other nonstratified series. However, the author readily acknowledges, that staging and reporting of staging is essential to the evaluation of various reconstructive procedures.

The critical question of when to forego repair for IVF-ET remains unanswerable in any absolute sense. So long as the continuing intrauterine pregnancy rate remains low for the latter approach, it seems probable that both the economics and the emotional investment of IVF-ET will encourage more infertility surgeons to become proficient and experienced in pelviscopic surgery.

Summary

The ultimate and most efficacious method of reestablishing patency and function of the fallopian tube has probably yet to be described. In a time of rapid and far-reaching technologic advances and burdensome health costs, however, it seems appropriate to consider the obvious advantages offered by the pelviscopic approach described. We will, of course, never know all of the answers, and so it is comforting to realize that James Thurber was probably right in encouraging us to just know some of the questions.

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11
Visual Documentation

JOHN M. LEVENTHAL

> One picture is worth more than ten thousand words.
>
> Chinese proverb

Successful surgery is of course the primary objective of every endoscopic procedure. On first glance, documentation of that surgery may seem to contribute little to the objective itself. Deeper reflection, however, will reveal to the thoughtful reader many areas in the overall evaluation of the patient and perhaps in the surgical procedure itself to which visual documentation is capable of lending clarity and continuity not otherwise attainable. Such understanding can contribute significantly to the success of the treatment as well as to better comprehension of the problem by both physician and patient.

Although few would argue that the technology explosion of the past 30 years has not been of extreme significance to our daily lives and to the practice of medicine, most of us would also decry our ability to acquire expertise in those technologies not immediately concerned with our ever narrowing spheres of medical interest. The result has been a decreasing ability to distinguish between those aspects of the expanding technology that are truly applicable to our practice and of help in the treatment of our patients and those that are merely appreciated as academically interesting or exciting. The technology connection is not always clear to even the most sophisticated. Who could have equated Neil Armstrong's "step for mankind" on the moon in 1969 with a two-ounce digital video camera for endoscopy in 1985? Yet, as we all appreciate now, the camera as well as a whole generation of technology is a direct result of that "step."

Examples of such areas of technology include charge coupled device (CCD) imaging, digital archiving, and nonsilver photography. Even the names seem foreign to the average practicing physician and beg the question, "What on earth is he talking about?" Yet such technical development has already resulted in significant change in the practice of today's medicine. Understanding the application of new technology has become as essential to the endoscopic surgeon as it has to colleagues in the more traditionally technically oriented professions.

In this chapter we will explore the technology of photographic and electronic imaging as applied to the documentation of pelviscopic surgical procedures. We will attempt to bring order to confusion and explain in clear terms those aspects of modern documentation technology that can be maximally useful to the surgeon in solving some of the problems faced in everyday practice.

What Is Documentation?

Documentation is simply the recording of observed phenomena. Every physician devotes significant time to the graphic recording, in one form or another, of what he or she observes in the practice of medicine. Most often it takes the form of written notes and diagrams, but occasionally it consists of radiographs, photographs, or electronic images. In each instance, the recording involves an attempt to preserve what is seen, heard, or thought about the patient. The purpose is not, as it often seems, to satisfy requirements of the record room or to protect against litigation but, rather, to assist in solving a problem, arriving at a diagnosis, or recording the specifics of treatment for future reference. Every form of documentation, therefore, is important to the physician in his or her role as health problem solver. However, most forms of traditional documentation are, to a greater or lesser degree, subjective. They often reflect as much of the background and prejudice of the observer as they do the object of observation. The written progress note or office note, or the dictated operative summary, is at best interpretive or, put in the vernacular of the modern technology, not transportable. Although it is probably true that no two individuals observing the same phenomenon "see" it the same way, it is also true that the act of "seeing" is the event from which most interpretations flow. As important as it is, visual observation constitutes only one of the bases for conclusions about the observed phenomenon. Consistency, odor, sound, and sometimes even taste also lead the physician to interpretations and conclusions. It has long been said that "seeing is believing," and in most cases we do indeed rely principally on what we see. The audiotape recording of an interview with a patient may be of utmost importance to the psychiatrist and as such would constitute a form of documentation especially helpful to the psychiatrist who conducted the interview. To another psychiatrist, however, the inability to associate the recording with facial expressions and body movement would constitute a significant deficiency in the data. To the pelviscopic surgeon, primarily concerned with problems of anatomic structure and function, there would probably be general agreement that visualization is the key element in the formulation of correct interpretation.

Documentation then, as we will discuss it here, means the acquisition, transportation, and storage of visual images in such a way as to make them available to a multitude of secondary observers, providing each with the fresh opportunity to draw conclusions based upon the "raw" observed material. We will discuss some of the underlying principles of various methods of documentation and provide some practical suggestions for the documentation of operative laparoscopy.

Types of Documentation

The recording of data concerning a medical procedure can take many forms and involve a variety of technologies from the simple ballpoint pen to the CCD. Each form may or may not be ideally suited to a particular application but may represent the best available to any one physician or in any one institution.

Written Documentation

For routine recording of surgical procedures, operative dictation is the form most widely used and the one most familiar to the surgeon. Its primary purpose, of course, is to record details of the operative procedure and observed findings for the patient's permanent record. Although intended to inform future readers exactly what was seen and done, for many reasons it usually fails to do so. Not infrequently it is left to the junior member of the operating team; many times it is merely a recitation of the details of the technique with little attention given to findings actually seen. Far too often the dictation is done long after the operation when it is impossible to accurately remember the findings or even exactly what was done.

It has been suggested by others that the operative report be complemented by a drawing of the general anatomy that would accurately identify abnormalities or lesions.[1] Unfortunately, the wide range of artistic talent found among surgeons makes this potentially useful addition quite variable both in its accomplishment and its value.

In today's litigious climate, the operative report—with or without an accompanying sketch—often assumes more importance for the medical record librarian and hospital administration than it does for the medical care of the patient. At its very best, it is only an *interpretation* of the findings and therefore never more than a subjective form of documentation.

Visual Imaging

Direct visual documentation, on the other hand, is usually objective. As applied to operative laparoscopy, it is accomplished by any one or a combination of three technical modalities: (1) still photography; (2) cine photography; and (3) video imaging. A photograph, movie, or videotape of the findings at surgery is a much more objective form of documentation than the written narrative or crudely drawn sketch. Although it is true that the subjectivity of the observer enters into the choice of what to document, the recorded findings most often speak for themselves and present essentially the same view to the secondary observer as they do to the surgeon. Although the surgeon at the operation has the advantage of using other sensory input in the interpretation of findings, visual images allow the next best approximation of objectivity for fresh interpretation by each person subsequently viewing the document. Optimally, visual documentation should be accompanied by a contemporaneous audio recording placed on the same tape. Although introducing an element of subjectivity, this method provides a recording of the surgeon's interpretations of what is seen and greatly aids the subsequent viewer in understanding the original findings. We will discuss the details of this type of documentation more fully in the sections to follow.

First, however, it is valuable when choosing the appropriate means of documentation to have a basic understanding of some of the principles of light and lenses that underlie all three forms of visual recording. The physician for whom these remarks are intended need not be a closet optical engineer to understand the optics of the instruments employed. The clinical value of the final document produced, however, will usually be directly proportional to the surgeon's knowledge and application of these basic principles.

All imaging involves the recording, on some light-sensitive medium, of an observed image. The medium itself may be sensitive to light directly (e.g., silver halide film), may be influenced secondarily by magnetic fields that are in turn dimensioned by light (e.g., magnetic videotape), or may be influenced by electronic signals, the value of which is determined by light (e.g., digital disks, laser disks). The degree of sensitivity of the medium to light in any documentation system is greatly dependent upon the type of recording equipment used. For example, it is usually necessary to provide more light for photographic recording than for electronic imaging, meaning that even very "fast" film is usually not as sensitive as the electronic light sensors of a microprocessor chip. In any case, the desired result of every recording is an image reproduced in a manner that renders it recognizable to the eye and that accurately represents the original object of observation. It correctly implies that the illumination of the object must be within the threshold of sensitivity of the primary recording medium; in other words, there must be sufficient light available to the documentation system to achieve intelligible imaging.

With all three systems used to document laparoscopic surgery, illumination of the observed object is provided by a separate light source designed to work with laparoscopic recording equipment. In most cases the light source is the same one used with the endoscope itself but, as is the case for most still photography systems, may contain a built-in electronic flash unit as well. As will be discussed, this latter arrangement is usually essential for obtaining good still color photographs of the procedure.

The optical axis, through which light must travel to the subject and return to the sensitized medium in the camera, is made up of the lens systems of both the camera and the laparoscope to which it is attached. The optical characteristics of this axis are subject to many factors that directly influence image quality. In order to achieve consistently useful visual documentation of the highest quality, the endoscopic surgeon will be well advised to take time to understand the interdependence of these factors as well as those basic principles that govern imaging and the lighting on which it depends.

Sufficient light for useful documentation depends on four variables: (1) the sensitivity of the recording system; (2) the light transmission efficiency of the lens system used with the recording equipment; (3) the illuminating power (usually expressed in lumens) of the light source itself; and (4) the size of the exposed image.

Sensitivity of the Recording System

In the case of film, depending on the photochemical characteristics of the silver halide emulsion used, sensitivity is expressed in terms of film "speed," or ASA rating. The higher the ASA rating, the "faster" the film and the more sensitive it is to exposure by light. The chemical reaction involves a silver halide salt that is dissolved to a greater or lesser degree in a developing solution depending on the quantity of light striking the emulsion at exposure time.

Based upon an entirely different set of physical principles, electronic imaging depends upon the electrical changes brought about in a semiconductor chip by light striking its surface. Two types of solid state microprocessor chip are in current use in medical video cameras: (1) the CCD; and (2) the metal-oxide semiconductor chip (MOS) (Fig. 11-1). Until recently the CCD had the advantage of greater light sensitivity but less resolution than the MOS chip. With the introduction of the negative metal-oxide semiconductor chip (NMOS) this difference has largely disappeared. Both types of chip currently have sensitivities of approximately 10 lux (units of electronic light sensitivity). Solid state electronics as applied to video imaging is a field that is changing so rapidly it is impossible to render a textbook discussion that will remain current for any length of time. Readers will be well advised to update their knowledge in this area at the time the purchase of new equipment is under consideration and, most importantly, to personally try out and evaluate systems when available.

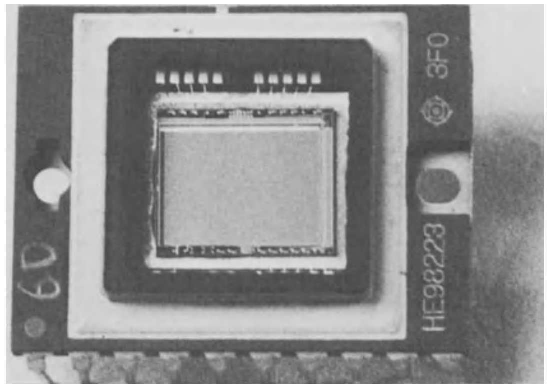

FIGURE 11-1. Charge-coupled device microprocessor chip used in video camera.

Light Transmission Efficiency

The quantity of light transmitted through lens systems is a function of the lenses themselves. It should be remembered that visual documentation in laparoscopy or pelviscopic surgery always involves multiple lens systems (i.e., lenses of the camera, the endoscope, and sometimes the fiberoptic light bundle). Each lens system serves to attenuate the quantity of light illuminating the subject and reflecting back to the recording medium. Each increment of attenuation is additive. In addition, quantity of light varies directly with the diameter of the fiberoptic bundle that carries the illumination, so that documentation is always better accomplished with large diameter laparoscopes.

The eye of the observer is often a critical factor in misleading the surgeon with respect to making a valid judgment about the lighting requirements of a particular situation. Most pelviscopic surgeons still make the initial observation of the pelvis with their own eye, directly through the laparoscope, although there is an increasing trend toward use of the video camera throughout the entire operation. The human eye, with its incredibly sensitive and adjustable optical apparatus, accommodates almost immediately to the pelvic lighting conditions provided by the setting of the light source in use and is almost always more sensitive than photographic film. What may seem quite adequate to the eye is often completely inadequate for the exposure of color film in a 35 mm format. If still color photographs of 35 mm size or greater are desired, a synchronized flash is essential. Interestingly, the sensitivity of the human eye, or at least its central nervous system interpretation, is very close to that of the microprocessor used in a video camera. What the eye can discern is usually captured clearly by the video camera. For this reason, as well as others, there is an advantage to making even the very first observation of the case from the video monitor with the camera attached to the laparoscope. In that way, what is displayed by the monitor is of virtually the same quality as that going onto the tape, and intraoperative adjustments can be made at any time the situation dictates.

Illuminating Power of the Light Source

Most of today's endoscopic light sources are installed with both incandescent and metal vapor arc lightbulbs, often labeled "diagnostic" and "photographic," respectively. These labels are somewhat misleading, as the brighter so-called photographic source is insufficient for most still photography although usually adequate for video imaging and some cinematography. Color temperature of the incandescent source is in the range of 4500°K, making it similar to a home light bulb, whereas the metallic arc emits light at a color temperature of about 6000°K and appears more blue to the observer. These differences in color temperature are important when choosing color film and filters for photography but have no measurable effect on the adequacy of illumination. For 35 mm still photography, neither light source will give sufficient illumination unless extremely fast film speeds are used or the object is filmed at very close range. There is actually very little to choose from when selecting a light source for pelviscopic surgery. Most manufacturers in the current market provide, in the same unit, both incandescent and arc bulbs. Many units are also equipped with a variable electronic strobe flash that can be automatically adjusted to the appropriate exposure by sensors located either in the optical axis of the camera or in the light source. To the credit of equipment suppliers, it should be said that in most cases, if the user instructions are followed carefully, consistently excellent still color photography can be accomplished with relative ease.

Size of the Image

With photographic documentation, adequate illumination will be determined by the size of the projected image on the light-sensitive medium (film). If the image area to be exposed is quite small (e.g., frame size of an 8 mm movie film), less light from the subject is necessary. If, on the other hand, the same amount of illumination adequate for such a small image area is used to expose a single 35 mm frame (which has an area approximately 87 times that of an 8 mm movie film), with the other variables constant, the resultant picture will be underexposed. This explains the reason a 350-watt metallic arc light source may be more than adequate for the exposure of 8 mm or 16 mm cinematographic film but inadequate for proper exposure of 35 mm film of the same ASA rating.

Therefore, when larger formats are used, faster film or more light is necessary. The faster the film speed (higher ASA rating) the less light is needed for proper exposure. Color print and transparency 35 mm films with ASA ratings of up to 1000 are now available, and have begun to make excellent pictures possible without the use of flash equipment. "Speed" of the lens system in use (laparoscope *and* camera) will also determine the amount of generated light necessary for proper exposure. The laparoscope component varies with the diameter of the scope: the smaller the diameter of the laparoscope, the fewer fibers available for light transmission, the less light transmitted, and therefore the more powerful the light source necessary to achieve usable imaging. For this reason, laparoscope diameters of no less than 10 mm are recommended for documentation. The camera component is dependent upon the "speed" of the camera lens, which is inversely proportional to the minimum value of the f/stop. An f3.5 lens is "slower" than an f1.0 lens and will therefore require more light.

Still Photography

Static imaging produces a "snapshot" of a single moment in the endoscopic procedure. The moment captured can be used for demonstration of a specific point for teaching or referral purposes or can be representative of the entire procedure for patient education. In the former instance, it is desirable to take a series of photographs that "freeze" a series of moments, demonstrating details of a particular technique or progression of a certain operative procedure. Sometimes a single picture of an observed abnormality will be extremely helpful to the referred consultant and in some cases may even obviate the necessity for another diagnostic laparoscopy. In pelviscopic surgery, color slides are extremely useful for the teaching of residents and colleagues and for the accompaniment of presentations.

Still pictures can be obtained in a number of formats. The most common is the conventional (noninstant) 35 mm color transparency, but 35 mm print film and instant formats are available and particularly useful for placing visual documents in the patient record. With the increasing availability of rapid conventional film processing, making it possible to have prints or slides within hours, instant photographic capability is less attractive than it once might have been for hardcopy documentation.

Reduced to the barest essential, the only additional equipment necessary in the operating room for obtaining still photographs is a camera and an adequate light source. However, considering the problems usually encountered in adapting the camera and lens system to the laparoscope, it is best to consider the purchase of a dedicated system. Most endoscope manufacturers, now recognizing the importance of visual documentation and the opportunity for sales, offer complete systems for the still recording of laparoscopic findings using distal strobe flash and automatic exposure control. Although usually more expensive than the adaptation of existing photographic equipment to laparoscopes and light sources already in use, automated systems allow the endoscopic surgeon to focus primarily on the procedure itself.

It may be that the camera-generated photograph will soon yield entirely to still another method of electronic imaging. "Frame grabbing" technology is now available, which allows for production of an instant print or conventional slide from any moment of continuous video recording. In practice it means that the surgeon using video monitor control for operative laparoscopy will merely need to press a button or step on a foot switch to obtain a digitally produced hardcopy "snapshot" of any chosen moment of the procedure.

Dynamic Imaging

If the ancient Chinese adage that a picture is worth more than 10,000 words is true, a continuous series of pictures (e.g., cine or video frames) is worth infinitely more. The most useful record of any laparoscopic procedure is a dynamic one. Whether recorded photographically (cine) or electronically (video), the "live" moving record of the procedure adds the dimension of time and makes the recording much more meaningful to the subsequent observer.

Cinematography

Before the advent of video imaging for endoscopic procedures, film motion pictures were the only form of dynamic imaging available and were usually reserved for the production of widely distributed teaching films. Because the format used was usually 16 mm color, the equipment was extremely cumbersome and quite restrictive with respect to which surgical procedures could be performed simultaneously. Although there is little argument that many of the teaching films of laparoscopy, and more recently of pelviscopic surgery, are of outstanding quality, they involve considerable time, money, and very special skills to produce. For routine documentation, 16 mm cameras are much too heavy and bulky. For a short time, again before the advent of usable medical video systems, a number of 8 mm cameras were marketed for surgical endoscopic cinematography, but they offered little advantage over their instant counterparts and gained only minor acceptance. In the early 1980s, Polaroid Corporation produced a medical model of their instant 8 mm movie camera that produced a 3- to 5-minute cassette of color film.[2] Although inexpensive, easy to use, and convenient for patient education, unfortunately the system proved too costly to manufacture, could not expect to compete with newly introduced video, and was withdrawn.

Today's electronic climate and high resolution miniature video cameras leave few practical applications for routine cinematographic documentation with conventional film. However, because the resolution of large-format color film has still not been matched by even the newest video technology, the one practical use for dynamic film imaging remains the production of well edited and scripted teaching documents destined for wide distribution and produced professionally.

Electronic Imaging

It was totally predictable that the introduction of the electronic medical image in the 1970s would darken, and eventually severely restrict, the future of increasingly expensive silver halide technology for dynamic imaging in medicine. For the reasons discussed above, and for many others as well, movie making proved simply too much trouble for practical application in pelviscopic surgery. The inevitable application of increasingly smaller microprocessors to video camera design in the 1980s has produced smaller, lightweight units with good resolution capable of providing a wide variety of video documentation in medicine. So fast has the technology grown that in mid-1987 the National Library of Medicine listed some 804 references on video applications in medicine.

The marriage of the video camera and the endoscope was a natural one from the beginning. Early on, the video camera became so essential to the arthroscopist that today very few arthroscopies are performed without instantaneous on-screen monitoring as the sole means of viewing the operative field. Diagnostic laparoscopy and operative pelviscopic surgery lend themselves equally well to this "all video" approach, which is slowly beginning to gain a significant and devoted following. With the capability of extreme miniaturization afforded by the microchip camera, an entirely new technical development has emerged—direct video endoscopy. This technology mounts the camera at the distal end of the endoscope and does not rely on a transmitting lens system to carry light to the microchip. Direct endoscopy was first developed for use with flexible gastrointestinal endoscopes but has been quickly adapted by a highly competitive industry to rigid laparoscopes as well. Satava's[3] comparison of direct and indirect video endoscope systems, with respect to resolution, brightness (luminosity), and color intensity (chroma), revealed the direct camera to produce the best overall video image.

The use of continuous video monitoring requires the pelviscopic surgeon to make some alterations in operative technique. The video camera must be attached directly to the eyepiece of the laparoscope and, unless a beam-splitter is used, will prevent the surgeon from direct visualization through the instrument itself. Orientation to this "indirect" viewing technique takes a little practice, but the skill is quickly acquired by most laparoscopists.

Continuous video monitoring offers a number of benefits that more than compensate for the inconvenience of learning to manipulate instruments from the monitor screen. Perhaps the greatest benefit has little to do with documentation but derives from allowing the surgery to be seen by all members of the operating team. No longer must the scrub nurse guess as to what is taking place at the operative site or try to take some meaning from the surgeon's occasional, and too often cryptic, comments. When all members of the team are working from the monitor screen, the surgeon can count on informed assistance in holding instruments and manipulating tissue. In addition, with the operation "open" to observation by more than one person, there is less chance that subtle abnormalities or potential dangers will be missed.

Because the video recorder can be switched on and off without interrupting the monitor picture, any or all parts of the procedure can be recorded at the discretion of the surgeon. It is sometimes convenient to record the entire procedure and to edit the resultant tape at a later time when there is the chance for retrospective assignment of importance to various aspects of the procedure. At other times, such as when a tape is prepared for teaching, it may be appropriate to be selective in choosing the material to be recorded. In every case, it is important for archival purposes to record those aspects of the procedure that bear directly on the diagnosis and treatment and to have sufficient continuity to ensure understanding by others at a later date.

A unique advantage of electronic imaging is its ability to combine simultaneous visual and audio signals on the same magnetic tape. It is best accomplished by simply having a condenser-type lapel microphone attached to the upper part of the surgeon's scrub gown just before starting the laparoscopic portion of the case. In some operating suites, a microphone is mounted permanently above the operating table and is patched as needed into the audio/video recording equipment. Verbal identification of the patient, along with a brief history, diagnosis, and treatment plan, make an excellent opening for the videotape and orients the subsequent viewer to the pertinent details. Throughout the case, the surgeon should comment on the findings and the details of the surgery. It can be done as a running commentary or can be limited to occasional remarks made at various key stages of the operation. In a very real sense, this nonvisual aspect of the documentation lends a third dimension, allowing the viewer to have a better feeling for what was being observed and experienced by the surgeon at operation. A laparoscopic video recording system is shown in Figure 11-2.

In addition to the incomparable record of pelviscopic surgery provided by videotape, one of the significant benefits is education of the patient. Few would argue with the importance of having an informed patient, with regard to both the general understanding and the treatment of any condition. No medium could be better for informing the patient than videotape. Having made the video document of the procedure, the pelviscopic surgeon should take the necessary time postoperatively, in each case, to review the videotape with the patient. This step provides the best opportunity and the best method for detailing the observed pathology and demonstrating the treatment accom-

FIGURE 11-2. Typical digital (CCD) video system for endoscopy. (Courtesy of Vistek Corporation, Santa Barbara, California.)

plished. Despite early criticism by colleagues, in almost 20 years of visual documentation of laparoscopic procedures, the author has yet to have a patient object to this method of being completely informed of the surgical findings and the basis for prognosis. On the contrary, the surgeon will usually be rewarded by having an enthusiastic audience for the viewing.

Storage and Archiving

Visual documents of pelviscopic surgery, like written documents, must be conveniently stored and easily retrievable if they are to be useful to others. The best storage might well be in the patient record; and in the case of still photographs, it is where at least some should be placed. Videotapes and movies, however, are more of a problem.

Before storage, and as soon as possible after the procedure, a routine process of review and editing is essential. A comfortable and properly equipped place to do it should be available. In the case of still pictures (of any format) a critical culling of nonrepresentative and poorly exposed slides or prints must be done with brutal objectivity. Some photographs should be placed in the patient's record (either affixed to the progress notes or stored in a marked envelop) and the remainder placed in an organized archive.

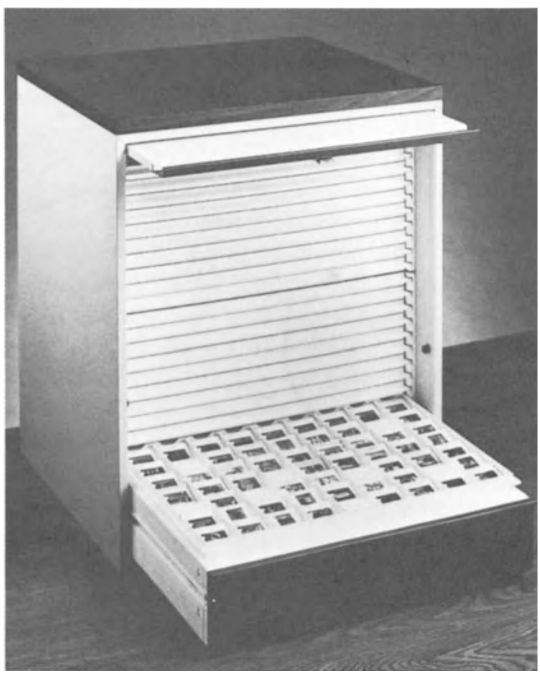

FIGURE 11-3. A 35 mm transparency storage cabinet with lighted tray for previewing. (Courtesy of Multiplex, Fenton, Missouri.)

```
Add Videotapes                                              F1   HELP
______________________________________________________________________

 Videotape: 1044

   Patient:                      Age:          Hosp No:

   Operation:
   Op date:
   Diagnosis:

   Key Words:
```

FIGURE 11-4. Data entry screen for computerized media identification system.

Videotapes should be stored in unedited form, although it is sometimes useful for purposes of clarity to make an edited second generation tape to show to the patient or colleagues. In any case, the review should take place as soon after the procedure as is practical. If the tape is to be used for teaching purposes, the patient's permission must be obtained and all identifying information edited out. The surgeon would be well advised to use the expertise of the hospital audiovisual department (if it exists) in the dubbing and editing of videotape or film.

The actual storage of documentation materials presents some problems in terms of space. Color slides can be kept in plastic slide sheets (20 to a page) in three-ring binders or, more expensively and more conveniently, in special storage cabinets (Fig. 11-3). Special storage boxes are available for videotapes (VHS or Beta). Ideally, photographic material should be kept in a dry, somewhat cool place. Such conditions rarely exist in the average physician's office, so the best compromise is to use a separate file cabinet located away from direct sunlight.

```
Search Videotapes                                                 F1   HELP
____________________________________________________________________________
                   This search has been based on the following:

  Age Range          Key Words          Diagnoses          Operations
  ___________        ___________        ___________        ___________
  25 to 35           TUBE               ENDOMETRIOSIS      LAPAROSCOPY


                             Age Range
                             _________
                             25 to 35


                   ---------[ Instructions ]---------

                      Are entries Correct? Y/N
                      Press   Esc   for Main Menu
```

FIGURE 11-5. Sorting screen for computerized media identification system.

Whatever the physical storage, it is critically important to any system that photographs, films, or videotapes are organized for quick identification and retrieval. For many years we have used a very simple system in which slides, films, and videotapes are assigned consecutive four-digit numbers preceded by the letter "S" for slide, "F" for film, and "V" for videotape (e.g., V12S4). As soon as they are returned from the processor, the obviously unusable slides are discarded and a numbering machine used to consecutively number the slides retained. The identifying data on the slide film, or tape are then entered in a simple computer database system using the following fields.

Document number	Patient name
Hospital number	Age
Date of procedure	Operation
Diagnosis	Key words

The fields for operation, diagnosis, and key words allow for the entry of up to 60 characters each, creating enough space for the description to fit most situations (Fig. 11-4). A videotape, film, slide, or groups of each can be retrieved easily by simply sorting the database or any one or a combination of the above database fields, printing out a list (if desired), and retrieving the material (Fig. 11-5). Each videotape, slide, or picture is filed alphanumerically. Nothing else need be considered. This system makes it easy to put together presentations for teaching, patient education, or conferences. As computers become more and more a part of the professional lives of most physicians, a system such as this one is rather easily implemented.

Videodisk Recording

There is little question that the archiving medium of the very near future will be laser recorded and/or laser read optical disks.[4–9] The interactive capability of videodisks that makes instantaneous retrieval possible also makes this medium ideal for interactive teaching.[10–16] Capable of storing enormous quantities of data, optical discs are rugged and capable of long life. For example, a small record only 8 inches in diameter is capable of storing some 15,000 color transparencies. Each "slide" in storage is a digitalized representation of the original and, from the electronic standpoint, is merely another record in a computer database. As such, it is instantly retrievable in exactly the same way that a bank balance might be retrieved on the family computer. It is extremely convenient to use but lends itself well to remote control. In fact, connected through telephone lines and modems, it is possible for someone lecturing on the East Coast to show the "slides" of a colleague in California without physically moving anything.

Until recently laser-recordable optical disks have been of the record-once-and-read-only type. Because actual pits are burned into the optical disk by the laser during the process of recording. A recent development by Sony Corporation (New York, NY), however, may make optical recordings as easily erasable as magnetic videotape.[17] The method uses what is known as Langmuir-Blodgett (LB) thin-film technology. LB films are extremely thin with 2.5- to 10.0-nm layers (10–40 molecules) of phthalocyanine. The application to optical disc recording uses mixtures of organic dyes in the film that are made to absorb light by predictable laser-induced disordering of their structure. By this process the laser writes information to the LB layer on the disk. The light-absorbing spots created in the LB thin film assume the same role as the pits in conventional laser recording and can be read by low intensity laser scanning. Erasure of the information on the disk is made possible by subjecting the LB layer to suitable temperature and humidity, which reverses the disordering and restores the layer to its original condition. Although currently used to erase entire disks, this technology should eventually permit the precise localized erasure of selected segments of information.

Using the same LB thin-film technology, Sony is currently developing a process to lay down multiple LB films sensitive to different absorbing frequencies, making it possible for a disk to hold several images separately accessed by lasers of different colors. Should this method prove to be feasible, the storage capacity of optical disks will increase sufficiently to make practical the storage of dynamic images, such as long sequences from videotapes or segments of digital imaging recorded directly onto the optical disk in the operating room.

It appears probable that within the next 5 years digital archiving for virtually all visual imaging will become routine. Physical storage space requirements will shrink to a fraction of that required by today's analog technology, and both local and remote retrieval will be almost immediate.

Sterilization of Documentation Equipment

With the exception of currently manufactured medical video cameras, it is not possible to sterilize those parts of the documentation system handled by the surgeon or that must be close to the operative field. It is therefore incumbent upon the surgeon to develop and follow a routine for documentation that minimizes the risk of bacterial contamination of susceptible tissue while at the same time allowing for informative visual documentation.

The newer video cameras, along with connecting cables, are carefully sealed to protect their electronic components against moisture and can be soaked in antiseptic solutions prior to use. Although contamination of any operative field should always be avoided, its importance varies with the area of the body contaminated. For example, the sterility of the video camera used for arthroscopy is crucial because the knee joint has a relatively low level of defense against bacteria. At the same time, contamination of the pelvic or abdominal cavities—lined with an active peritoneum serving to rapidly isolate and destroy invading bacteria—is almost never of clinical importance so long as it is not continuous. Thus, the arthroscope camera must be draped, whereas the laparoscopy camera can be handled by the surgeon once the intraabdominal instruments have been placed. In practice, it simply means that the surgeon double-gloves for the initial use of the camera and placement

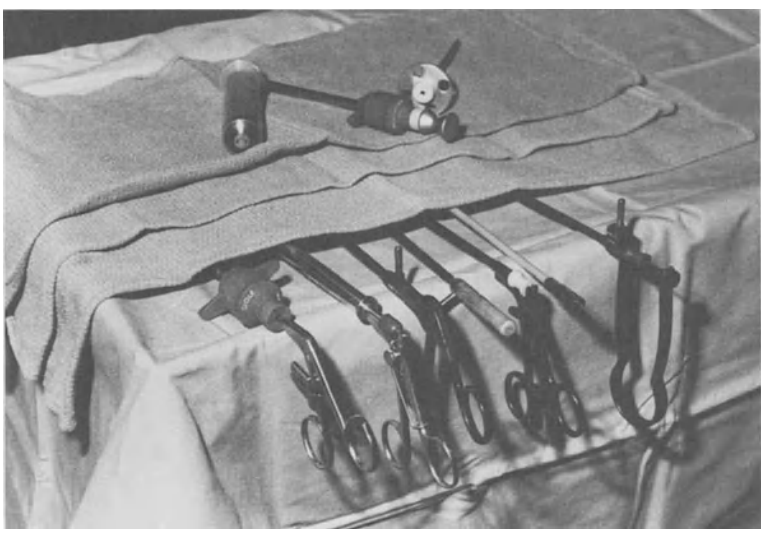

FIGURE 11-6. Secondary puncture site instruments replaced on the operating table with the "contaminated" ends off the sterile field.

of the first secondary puncture instruments. After this step is accomplished, whenever an instrument is removed from the abdominal cavity it is placed with the distal (sterile) end on the surface of the instrument table with the proximal (contaminated) end extending off the edge of the table (Fig. 11-6). Care is taken to avoid handling any part of the cannulas, so that secondary instruments will not be contaminated on insertion.

It is, of course, possible to place the camera and cable in a sterile transparent plastic drape. A number of such drapes, designed for arthroscopy, can be used for laparoscopy. Such precautions are perhaps in order for the use of a large cine or still camera, but, in practice, are almost never taken with smaller video cameras. An intermediate alternative is to have the surgeon double-glove and remove the outer gloves before handling any sterile instrument. Both of these methods of preserving the bacterial integrity of the operative field fall far short of true barrier protection and, in this author's view, are not recommended for either laparoscopy or pelviscopic surgery. Intraabdominal infection resulting from technique contamination is extremely rare, vindicating the common use of nonsterile documentation equipment at laparoscopy.[18]

Conclusion

Visual documentation in an increasing number of areas of medicine in general, and in pelviscopic surgery in particular, has a vital role to play in both the evaluation and treatment of the patient. Acquiring skill in documentation techniques should therefore be an integral part of the training for laparoscopy and pelviscopic surgery. The tremendous advances in technology of the past decade have given the pelviscopic surgeon an impressive array of documentation equipment with which to record and store findings and procedures. So rapid is the technologic pace that there is an incremental increase in both image quality and ease of application almost monthly. In any single physician and institution setting, however, there is no need to constantly update equipment and facilities to match the cutting edge of development. The documentation objectives should be decided upon, then simple quality equipment obtained, thoroughly learned, and used until it no longer satisfies the requirements of that setting. The pelviscopic surgeon should work through the institutional administration to assist in the development of documentation skills for those members of the medical team involved with endoscopy and should be personally involved in training both nursing and medical personnel. Because any recording of observed phenomena is useful only if it is easily retrievable, an orderly approach to storage and archiving is an essential part of visual documentation.

It is exciting to practice medicine at a time when excellent visual documentation is no longer the sole province of the biomedical photographer or the physician avocationally interested in what used to be considered the difficult and complex art of medical photography. A wide range of inexpensive visual documentation technology is available today, making it possible for most physicians to easily obtain and retrieve useful and objectively accurate records for an expanding variety of uses.

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12
Anesthesia

LINDA F. LUCAS and BENJAMIN M. RIGOR

Advanced operative and laser laparoscopy have become commonly accepted procedures. General, regional, and local anesthesia have all been used widely and safely for laparoscopy in hospitals and medical centers thoughout the world. Advancements in anesthetic and surgical techniques have decreased complications and recovery time while increasing patient acceptance of laparoscopy as an outpatient procedure. The choice of anesthetic technique varies with the requirements of the surgeon, the health status and preference of the patient, the type of facility, and the availability of well-trained professionals, support personnel and equipment. This choice can be made intelligently only when the physiologic changes that accompany the procedure are known and the surgeon and anesthesiologist are familiar with them.

Physiologic Changes During Laparoscopy

The complications of laparoscopy are few[1,2] (Table 12-1). Increased understanding of the physiologic changes that occur during anesthesia for endoscopy can perhaps further decrease the incidence of complications. Trendelenburg position and pneumoperitoneum have been shown to alter respiratory mechanics and physiology.

Effects of Positioning

The patient, as noted in Chapters 2 and 3, is placed in the Trendelenburg position (15°–20°) so that the abdominal viscera are moved cephalad. The steep Trendelenburg position in combination with the lithotomy position is known to impair ventilation and pulmonary mechanics.[3–5] In healthy, conscious patients placed in this position, vital capacity and functional residual capacity are decreased by 18% and 14.5%, respectively, as a result of compromised diaphragmatic excursion and increased pulmonary blood volume.[6] Under general anesthesia, the lithotomy position alone causes a 3% decrease in tidal volume; when combined with a 20° Trendelenburg position, there is a 15% decrease in tidal volume.[7,8] Pulmonary compliance is also altered,[9] especially in the obese patient.[10] This fact, in combination with alterations in distribution of inspired air within the lungs[11] and a diminished functional residual capacity, predisposes the patient to postoperative pulmonary atelectasis and possibly pneumonia. Other investigators have measured a reduction in functional residual capacity without consistent alterations in tidal volume, respiratory rate, minute volume, or oxygen consumption in conscious patients[11] and young, healthy women undergoing short, minor gynecologic procedures under light general anesthesia.[12] This maintenance of homeostatic respira-

TABLE 12-1. Complications of gynecologic endoscopy

Surgical complications affecting anesthetic management
Major vessel injury/hemorrhage
Bowel injury
Perforation of the uterine fundus
Abdominal wall hematoma
Anesthetic complications
Cardiac arrhythmias
Hypotension
Hypertension
Hypoxia
Hypercarbia
Acid-base disturbance
Pneumothorax/pneumomediastinum (barotrauma)
Pulmonary aspiration
Gas embolism
Gastric dilation/perforation
Prolonged artificial ventilation/apnea

tory function may be compromised under deeper general anesthesia, especially with longer procedures[13] as described in this book.

In most cases, the respiratory alterations produced by lithotomy and combined lithotomy and Trendelenburg positions in the patient undergoing general anesthesia can be corrected with a cuffed endotracheal tube and assisted or controlled ventilation. Reduced respiratory volumes can then be restored to normal and compressed basal lung areas ventilated to counteract the deleterious effects of positioning.

Effects of Pneumoperitoneum

Air, carbon dioxide, or nitrous oxide with intraabdominal pressures of 12–16 mm Hg are used to facilitate laparoscopy. Carbon dioxide is preferred because it decreases the incidence of gas embolism. It has been shown that carbon dioxide used in experimental animals is at least five times safer than oxygen.[14] The toxicity of the gas appears to correlate inversely with its solubility in blood. Carbon dioxide is the most soluble; nitrous oxide is only 68% as soluble as carbon dioxide in blood.[15] Although carbon dioxide appears to be more effective than nitrous oxide or air in reducing the incidence of gas embolism, it has been reported to cause increased intraoperative discomfort in awake patients undergoing procedures with local anesthesia.[16] This discomfort probably results from the combination of carbon dioxide with peritoneal fluid to form carbonic acid, which irritates the diaphragm and peritoneal lining.[17]

In early studies, following insufflation of carbon dioxide, patients who were breathing spontaneously and had been anesthetized with halothane and a nitrous oxide/oxygen mixture demonstrated a significant increase in expired carbon dioxide concentrations and an increase in respiratory rate by as much as 75–100%.[16] Minute ventilation was increased despite reduced tidal volumes.[16,18,19] The findings were consistent with both the depressant effects of halothane on respiratory drive, the depressant effects of premedicants, and further depression produced by increased intraabdominal pressure from carbon dioxide insufflation.

A tendency toward respiratory and metabolic acidosis was demonstrated by a significant decrease in arterial pH.[11,14,20,21] Decreases in arterial oxygen tension were reported, with values occasionally as low as 46–64 torr when the inspired oxygen concentration was less than 40%.[22] Another study demonstrated no evidence of hypoxia when ventilation was controlled with a gas mixture containing at least 30% oxygen. When nitrous oxide was used as the insufflating medium, no increases were seen in carbon dioxide tension values and pH values were unchanged, suggesting that intraperitoneal insufflation of carbon dioxide contributed to the acidosis. Absorption of peritoneal carbon dioxide added approximately 8 torr to the arterial carbon dioxide tension when compared with controls using nitrous oxide intraperitoneally.[23] No significant difference was seen between the two groups, one using carbon dioxide and the other nitrous oxide, in terms of base deficit or oxygen tension values.

Absorption of peritoneal nitrous oxide may contribute to postoperative diffusion of this gas into the alveolar space resulting in hypoxia.[24] This diffusion hypoxia, however, may be avoided with the postoperative administration of supplemental oxygen during recovery, which is recommended for all patients. Rare complications of nitrous oxide administration include entry of the gas into hollow viscera such as emphysematous bullae of the lungs resulting in spontaneous pneumothorax and, on one occasion, diffusion into an ovarian cyst.[25]

Spontaneous Versus Controlled Ventilation

Initial reports warned of the danger of spontaneous ventilation in patients undergoing laparoscopy with carbon dioxide insufflation.[18,23,26] Regardless of whether carbon dioxide or nitrous oxide is used as the insufflating medium, increases in carbon dioxide concentration may be avoided by using mild to moderate hyperventilation with assisted or controlled ventilation. Moderate hyperventilation sufficient to eliminate excess carbon dioxide in an adequately relaxed patient has been suggested as a means of maintaining respiratory and acid-base homeostasis[22,24,27] as well as avoiding cardiovascular instability that has been attributed to changes in arterial chemistry.[18] Later investigations questioned the advisability of assisted ventilation, as even higher mixed expired carbon dioxide concentration and carbon dioxide output result after completion of the surgical procedure and release of the pneumoperitoneum. Ventilatory techniques used during gynecologic endoscopy should have little effect on hypercarbia occurring after completion of anesthesia.[19]

Respiratory Changes Under Local Anesthesia

Minor laparoscopic procedures under local anesthesia with an awake, spontaneously ventilating patient are commonly performed safely with experienced personnel. In the Trendelenburg position, a slight increase in minute ventilation has been demonstrated that was caused by an increase in respiratory frequency. The tidal volume remained essentially unchanged. During pneumoperitoneum, a large increase in minute ventilation results from an increase in respiratory rate with a small decrease in vital capacity. Vital capacity, however, remains sufficient for patients to increase tidal volume, if necessary.[19] Arterial carbon dioxide tension, pH, and base excess are not significantly changed during the procedure. Mean arterial carbon dioxide tensions and pH in the awake patient are consistent with an acute hyperventilatory state and respiratory alkalosis. Mechanical compression of the lung by diaphragmatic elevation due to Trendelenburg position and pneumoperitoneum may alter pulmonary stretch receptors, causing the increased work load and increased respiratory rate.[27] Pain and anxiety also may contribute to the altered pattern of breathing and arterial blood gas values.

Respiratory depression may occur when the awake patient is premedicated with intravenous diazepam and fentanyl, meperidine, or fentanyl alone.[1] A general decrease in arterial carbon dioxide tension with no significant change in pH and arterial carbon dioxide tension,[27] or mild respiratory acidosis consistent with an elevated arterial carbon dioxide tension is seen when compared with values prior to sedation.[17]

Cardiac Arrhythmias

Cardiac arrhythmias occur at a rate of 27% during laparoscopy. The most commonly observed electrocardiographic changes are episodes of sinus tachycardia, ventricular arrhythmias, and asystole.[18,19,26] It has been postulated that these arrhythmias are the result of rising carbon dioxide tensions in anesthetized patients breathing spontaneously, especially when carbon dioxide is used for insufflation. Increased carbon dioxide tensions may cause arrhythmias. Although electrocardiographic changes occur during pneumoperitoneum, arrhythmias most commonly occur in the preinsufflation period.[2] Carbon dioxide tensions are highest after completion of the surgical procedure following release of the pneumoperitoneum[19]; therefore, it is unlikely that elevated carbon dioxide tension is the etiology of these arrhythmias or that the choice of controlled or spontaneous intraoperative ventilation is as important as maintenance of adequate minute ventilation.

Other causes of arrhythmias include hypoxia and vasovagal reflexes from peritoneal stimulation and distention, light anesthesia, and tracheal stimulation from the presence of an endotracheal tube. Vasovagal reflex stimulation resulting in hypotension and bradycardia occurs in 3.4%–14.0% of awake, sedated patients undergoing laparoscopic sterilization under local anesthesia.[22]

Patients with paracervical block in addition to local infiltration rarely develop bradycardia. Vagal stimulation arising from uterine motion and tubal compression is presumably abolished by the paracervical block. Atropine may be given prophylactically to block vasovagal reflexes, but it appears to have no advantage over prompt symptomatic administration. Vasopressors may also be indicated in the awake patient who experiences nausea in association with hypotension resulting from vasovagal stimulation. Antiemetics are seldom indicated, as this complication promptly responds to cessation of the stimulation.

Hemodynamic Alterations

Other changes in hemodynamic and cardiovascular parameters have been observed. Although pulse rate and systolic pressure remain steady in the supine patient during spontaneous ventilation with halothane,[19] significant increases in mean arterial pressure, pulse rate, and central venous pressure have been reported with Trendelenburg position.[20] Hypotension has also been reported as a result of cardiac arrhythmias and excessive intraabdominal distention. Compression of the inferior vena cava impedes venous return especially in patients who are already hypovolemic, such as in the immediate postpartum period. Decreases in systolic pressure, pulse pressure, central venous pressure, and cardiac output may result from intraabdominal pressures above 20 cm of H_2O.[21] High intraperitoneal pressure may also raise intrathoracic pressure, causing decreased chest wall compliance, increased peak airway pressures, and increased intrapulmonary vascular resistance. For these reasons, laparoscopy may be contraindicated in the patient with severe cardiorespiratory disease such as ischemic heart disease, mitral valvular insufficiency, or other congenital or acquired cardiac conditions with pulmonary hypertension and low or fixed cardiac output.

Gas embolization should be suspected in a patient with sudden and profound hypotension or cardiovascular collapse. It may result from intravascular administration of air through the Verres needle or direct injection of air that is absorbed by the uterine venous sinuses.[28] However, it is extremely unlikely that air would ever be used for insufflation. Auscultation of a precordial "mill wheel" murmur, elevation of central venous pressure, detection of air bubbles by ultrasound, and decreased end-tidal carbon dioxide measured by capnography (measurement of expired CO_2 levels) confirm the diagnosis. If carbon dioxide is the insufflating gas, the patient must be turned to the left lateral decubitus position to reduce right ventricular outflow obstruction until the gas is absorbed or aspirated from the right atrium through a central venous catheter. Nitrous oxide should be discontinued, and administration of 100% oxygen is mandatory.

Hypoxia may be associated with hypotension in cases of low inspired oxygen tension and spontaneous ventilation with halothane, nitrous oxide, and oxygen. Therefore, an oxygen concentration of more than 35% should be used at all times. Young women may develop hypoglycemia that intensifies the hypotensive response to moderate hypoxia. Patients should therefore be scheduled for surgery early in the morning. If surgery is to be performed in the afternoon, a small amount of clear liquid may be consumed 6 hours prior to surgery.

Selection of Anesthetic Technique

The anesthetic technique for a given surgical procedure should be as safe as possible, be the least likely to cause physiologic disturbance, and involve the shortest possible recovery time. As stated previously, the choice of technique is determined by the personal preferences of the anesthesiologist and the surgeon, the condition of the patient, the extent of surgery, the available facilities, and the presence of support services and personnel. Until the early 1970s in the United States, most surgical procedures in obstetrics and gynecology were performed under general, spinal, or epidural anesthesia in hospital operating and delivery rooms. With concern for safety and economy, gynecologists are now performing an increasing number and variety of procedures in outpatient or ambulatory surgical facilities. Laparoscopy is commonly performed under general, regional, or local anesthesia.

General Anesthesia

Advantages versus Disadvantages

The majority of gynecologic endoscopic procedures are still performed under general anesthesia. General anesthesia may be performed safely in free-standing and outpatient surgery units, as well as traditional inpatient facilities. Advantages include complete analgesia, amnesia, a quiet surgical field, and excellent muscle relaxation. Ventilation may be assisted or controlled to prevent atelectasis and hypercarbia especially in obese individuals. The patient's airway can also be protected against vomiting and aspiration with a cuffed endotracheal tube.

The anxious patient may prefer to be unconscious, and some surgeons consider an asleep patient ideal for this procedure. General anesthesia is suitable for the novice as well as the experienced endoscopist and is preferable in the initial training of residents until smooth, gentle control of equipment and viscera can be accomplished.

Disadvantages of general anesthesia include prolonged recovery and an increased incidence of major and minor sequelae. Gastric dilation may occur with poor mask fit or vigorous ventilation prior to intubation. Pneumothorax or barotrauma may also result from increased airway pressure during controlled ventilation, especially in the emphysematous patient with pulmonary blebs. Perioperative aspiration may occur even in the presence of an endotracheal tube.

Hoarseness, sore throat, and muscle pains are frequent sequelae to intubation. Minor postoperative complaints include prolonged recovery, nausea, vomiting, lethargy, and weakness. These complaints generally resolve within 24–48 hours. Postoperative morbidity is highest in female patients undergoing their first anesthesia, especially if it lasts more than 20 minutes or requires endotracheal intubation.[29]

General anesthesia is more costly than local anesthesia. Specially trained personnel and equipment are required during the procedure, as well as during the recovery period.

Laser Surgery

General anesthesia, with controlled ventilation, is most often employed for laser laparoscopy because it provides most effectively a motionless operative field for delicate surgical procedures. Alcohol, ether, and combustible gases may be ignited[30] by the laser beam or its reflection and should be avoided. Because nitrous oxide is a flammable gas, carbon dioxide is generally employed for pneumoperitoneum when intraabdominal procedures are performed. Nitrous oxide has the additional disadvantage of distending air-filled cavities. Significant bowel distention during prolonged surgery may cause impaired visualization and manipulation of pelvic structures, as well as an increase in the danger of bowel burns. Because carbon dioxide causes peritoneal and diaphragmatic irritation, the patient is spared this discomfort with the use of a general anesthetic. The patient is also not directly exposed to the noxious laser plume that may be frightening to the uninformed patient, as well as irritating to respiratory tissue.

Patient Selection

Patient selection for general anesthesia most appropriately includes patients suspected of having dense adhesions from intrapelvic pathology or previous surgery or those requiring extensive endoscopic surgery, especially when a second or third incision is to be made for introduction of an additional trocar. Patients with excessive fear of pain or awareness during surgery or patients who cannot relax or cooperate for office examination may require general anesthesia. This population may include patients with a language barrier, mental retardation, severe hearing loss, or physical anomalies that make pelvic relaxation or positioning difficult.[31]

General anesthesia may be the optimal choice for obese patients. There is severe respiratory impedance following insufflation for the pneumoperitoneum, even in the well-ventilated, nonobese patient.[23] Such impedance can be expected to be even greater in the obese patient who already has decreased respiratory compliance and increased airway pressure at a given lung inflation volume.[24] Patients with decreased lung volumes, particularly those with decreased vital capacity and functional residual capacity producing a restrictive pulmonary defect, are at increased risk of acute respiratory insufficiency and postoperative atelectasis. Some young obese patients may not tolerate the Trendelenburg position comfortably. Absorption of intraperitoneal carbon dioxide used for insufflation may further compromise the patient suffering from obese hypoventilation syndrome (pickwickian syndrome) or supine hypotension secondary to obesity.

The preference of the surgeon is also an important consideration. However, it is understood that pelviscopic surgery and laser laparoscopy often require general anesthesia. Some surgeons object to local or regional anesthesia for short laparoscopic cases because their training or inexperience with awake patients makes them more comfortable when the patient is asleep. The surgeon may be unwilling to subject patients to even slight discomfort. To succeed with local anesthesia for laparoscopy, the gynecologist must be able to perform various procedures with gentleness, confidence, and skill. He or she must be sensitive to the physiologic and psychologic needs of the patient. Many physicians wish to avoid the distraction of communicating with the patient during surgery. If laparoscopy is performed in a training institution, it is much easier to demonstrate techniques and procedures when the patient is asleep. The surgeon, as well as the anesthesiologist, may find local anesthesia cumbersome and may want to avoid the extra minutes spent in administering local or regional anesthesia.

Quite often the previous experience of the surgeon or anesthesiologist plays a role in the decision to use a particular anesthetic technique. Local anesthesia, with monitored anesthesia care, sedation, and analgesia, is often chosen for critically ill patients. Attempts at local techniques in these poor-risk patients under less than optimal conditions may result in failure and loss of confidence in local anesthetic techniques. The surgeon and anesthesiologist may then be put in the difficult and dangerous position of inducing general anesthesia after the procedure has begun.

Premedication

Realistic goals of premedication are to reduce anxiety, nausea, and vomiting; to augment induction; to produce reliable sedation, amnesia, and analgesia; and to reduce anesthetic requirements. Choice of premedicants is influenced by the anesthetic technique employed, emotional and physical condition of the patient, and preference of the anesthetist. Premedicants generally include anxiolytics, narcotics, antihistamines, hypnotic sedatives, antacids, antiemetics, and other pharmacologic agents (Table 12-2).

Almost all patients are anxious preoperatively. There is no substitute for counseling and reassurance by the surgeon, nursing staff, and anesthesiologist concerning expectations for the conduct of the procedure, pain relief, and type of anesthesia. Such counseling should be accomplished in the surgeon's office and in the preoperative preparation area by sympathetic, considerate, confident, and experienced staff.

Although barbiturates were once widely utilized as preoperative oral medications, intravenous benzodiazepines have become the mainstay of preoperative anxiolytic therapy. They are generally given immediately before or upon arrival in the operating room. Diazepam (Valium; Roche, Nutley, NJ) has been the most popular agent. However, it is being replaced by the newer, water-soluble, shorter-duration agent midazolam (Versed; Roche). Midazolam, like diazepam, is an excellent anxiolytic and amnestic drug. There is less vascular irritation, burning on injection, and thrombophlebitis, which are commonly reported with diazepam. Postoperatively, however, there may be no difference in speed of recovery of psychomotor function.[32]

An additional advantage to premedication with the benzodiazepines is their anticonvulsive effect, which may raise the toxic or seizure threshold of local anesthetic agents.[33] It must be remembered, however, that benzodiazepines have no analgesic effect and must therefore be combined with a narcotic. Morphine, meperidine (Demerol; Winthrop-Breon, New York, NY), and fentanyl (Sublimaze; Janssen Pharmaceutica, Piscataway, NJ) are suitable. The occasional disinhibitory effect of the benzodiazepines must also be considered, as it may cause some patients to become garrulous, restless, or uncooperative. Other recently reported problems with midazolam are somnolence and occasional apnea in awake patients.[34]

TABLE 12-2. Premedication for adults undergoing gynecologic endoscopy[a]

Drug	Dosage (mg)	Route of administration
Anticholinergics		
Atropine sulfate	0.4–0.8	IM or IV
Scopolamine	0.4–0.6	IM or IV
Glycopyrrolate (Robinul)	0.2–0.4	IM or IV
Gastric antisecretagogues		
Cimetidine (Tagamet)	200–400	PO, IM, or IV
Ranitidine (Zantac)	50–150	PO, IM, or IV
Famotidine	10–20	IV, PO
Antiemetics (antinauseant)		
Droperidol (Inapsine)	0.0625–0.125	IM or IV
Promethazine (Phenergan)	7.5–25.0	PO, IM, or IV
Metaclopramide (Reglan)	10–20	PO, IM, or IV
Sedatives & anxiolytics		
Diazepam (Valium)	5–20	IV
Hydroxyzine (Vistaril)	25–100	IM
Midazolam (Versed)	2.5–5.0	IV, IM
Analgesics (narcotics-opiates)		
Alphaprodine (Nisentil)	15–45	IM or IV
Fentanyl (Sublimaze)	0.050–0.15	IM or IV
Meperidine (Demerol)	25–100	IM or IV
Morphine sulfate	5–10	IM or IV

[a] Typical 70 kg ASA class I to II patients; geriatric patients will require a dose reduction up to one-third of the above mentioned dosages.

Because laparoscopy is often performed as an outpatient procedure, it must be emphasized that outpatients presenting for surgery and anesthesia have an increased risk of aspiration and subsequent pneumonitis due to higher gastric volumes and lower gastric pH levels compared to those of inpatients undergoing similar procedures[35] (Fig. 12-1). At particular risk are obese patients, pregnant women with increased intragastric pressure, and patients with hiatal hernia. Premedication with metoclopramide (Reglan; A.H. Robins, Richmond, VA), antihistaminic agents (H_2 antagonists) such as ranitidine (Zantac; Glaxo, Research Triangle Park, NC) or cimetidine (Tagamet; Smith Kline & French, Philadelphia, PA),[36] or a nonparticulate antacid such as sodium citrate (Bicitra; Willen Drug Co., Baltimore, MD) should decrease the incidence and morbidity associated with gastric acid aspiration.

Metoclopramide,[37] droperidol[38,39] (Inapsine; Janssen Pharmaceutica) and other butyrophenones, phenothiazines (Compazine; Smith Kline & French; Phenergan; Wyeth, Philadelphia, PA), and various antihistamines (H_1 antagonists) such as hydroxyzine[40] (Vistaril, Pfizer, New York, NY) may also be useful for sedation and prevention or treatment of perioperative nausea and vomiting.[41] These drugs may be given preoperatively, intraoperatively, or postoperatively in small doses as needed. In large doses, however, they may delay recovery and ambulation.

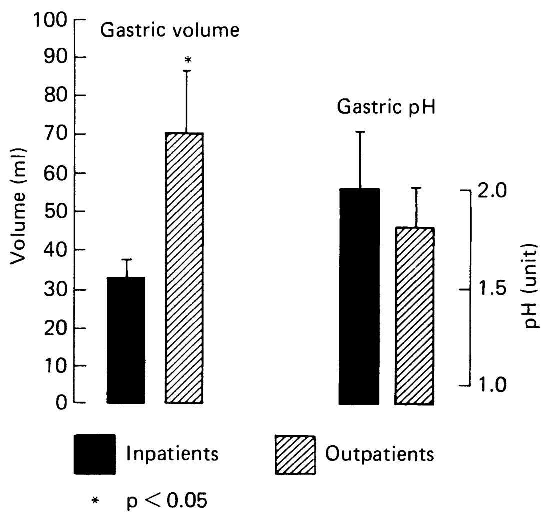

FIGURE 12-1. Comparison of mean gastric volume and pH values at the time of induction of outpatients and inpatients. (From Ong et al.[35])

Short-duration narcotics such as fentanyl[42] or narcotic agonist-antagonists such as nalbuphine (Nubain; DuPont Pharmaceuticals, Wilmington, DE) and butorphanol (Stadol; Bristol, Syracuse, NY),[43] are gaining wide acceptance. Rapid recovery and the absence of respiratory depression by agonist-antagonists make them very useful in the outpatient setting. In combination with small doses of benzodiazepines, these drugs can be expected to provide sedation, analgesia, and amnesia for operative events without delaying recovery and ambulation. Indeed, such premedicants may actually shorten recovery time by reducing the dosage of the anesthetic agent required.

Techniques

Frequently anesthesia is induced with a rapid-acting barbiturate such as methohexital (Brevital; Eli Lilly, Indianapolis, IN) or thiopental sodium (Pentothal; Abbott, North Chicago, IL) administered intravenously. Methohexital has gained popularity in the outpatient setting because it allows more rapid awakening and recovery compared to thiopental. It does, however, produce a high incidence of adverse side effects, such as pain on injection, hiccoughs, and myoclonus. Thiopental, when utilized, must be administered judiciously to avoid delayed or prolonged recovery. Etomidate (Amidate; Abbott) compares favorably with methohexital for outpatient induction of anesthesia.[44,45] However, etomidate causes a high incidence of nausea, vomiting, and involuntary motor activity, and may produce transient suppression of postoperative adrenocortical function.[46] Ketamine hydrochloride (Ketalar; Parke-Davis, Morris Plains, NJ) has been shown to produce undesirable psychomimetic effects in patients undergoing minor gynecologic procedures[47] (see Table 12-3).

All patients undergoing gynecologic endoscopy are at risk for aspiration pneumonitis as a result of passive or active regurgitation and subsequent hypoxia and/or cardiovascular collapse. A cuffed endotracheal tube should be properly placed and secured to protect the airway. It is also advisable to pass an orogastric or nasogastric tube and aspirate the stomach contents prior to gas insufflation for pneumoperitoneum. The tube should be suctioned intermittently to relieve gastric dilation resulting from assisted ventilation with an anesthesia face mask prior to intubation or to relieve gas absorbed into the stomach from the pneumoperitoneum.

Maintenance of anesthesia can be provided with inhalational agents or intravenous agents. Fluothane (Halothane; Ayerst, New York, NY), enflurane (Ethrane; Anaquest, Madison, WI), and isoflurane (Forane; Anaquest) have all been successfully used. Although enflurane is a potent respiratory and cardiovascular depressant, its use is generally preferred in outpatient procedures because of rapid recovery and fewer side effects.[48] Fluothane may predispose the patient to life-threatening arrhythmias,[18,19,26] particularly when a local anesthetic solution containing epinephrine is administered by the surgeon or when it is administered to a patient with elevated levels of plasma catecholamines due to anxiety, hypercarbia, and acidosis. Enflurane and isoflurane are associated with fewer arrhythmias in the presence of increased circulating catecholamines. In patients receiving enflurane for anesthetic maintenance, no difference in the incidence of arrhythmias has been noted between a mechanically ventilated group and another group of patients breathing spontaneously.[2]

TABLE 12-3. Anesthesia for laparoscopy

General anesthetic techniques
Inhalational anesthesia
Intravenous/narcotic (balanced)
Regional anesthetic techniques
Spinal
Epidural
Local anesthetic techniques—field block
Including/without paracervical block
Including/without intraperitoneal block
Including/without local anesthetic block
Single vs. multiple incisions

Fentanyl and a shorter-duration narcotic derivative, alfentanil (Alfenta; Janssen), appear to be safe and effective. In a balanced anesthetic technique with nitrous oxide and oxygen, fentanyl is commonly used for both inpatient and outpatient procedures. The popularity of fentanyl depends on its potent analgesic properties, rapid elimination or reversal, and cardiovascular stability.[49] Concerns about the safety of fentanyl in outpatient surgery involve the likelihood of postoperative respiratory depression and nausea and vomiting commonly associated with opiate analgesics. When used in moderate doses with nitrous oxide and oxygen, the respiratory depression produced by fentanyl often requires reversal with an antagonist such as naloxone (Narcan; DuPont Pharmaceuticals) or a combined agonist-antagonist such as nalbuphine or butorphanol to avoid the necessity for postoperative controlled ventilation. The newer, ultra-short-duration fentanyl analog alfentanil may be used for induction and maintenance of anesthesia with either bolus or continuous infusion without postoperative respiratory depression and the complications associated with narcotic reversal. Fentanyl and alfentanil anesthesia produce less cardiovascular depression and can be used safely in high risk as well as healthy patients. Although outpatients receiving a balanced anesthetic technique incorporating short-acting narcotic agents develop a high incidence of early postoperative morbidity, the incidence of these complications does not differ significantly following discharge from those inpatients receiving inhalational agents.[50] Outpatients have a high incidence of minor side effects such as nausea and vomiting for up to 48 hours postoperatively regardless of the general anesthetic technique employed.[51]

The choice of muscle relaxants as adjuncts to general anesthesia for short procedures was limited prior to the introduction of the intermediate-duration drugs. Succinylcholine (Anectine; Burroughs Wellcome, Research Triangle Park, NC), a depolarizing muscle relaxant, is commonly used in a bolus form for rapid intubation and as an infusion (0.1–0.2%) for maintenance of muscle relaxation. It causes frequent minor side effects, such as muscle soreness, and occasional serious complications, including bradycardia, hyperkalemia, myoglobinemia, malignant hyperthermia, and rarely prolonged apnea in patients with plasma cholinesterase deficiency.[51] These problems can be avoided with the use of nondepolarizing agents. Until recently, however, there were no agents suitable for short surgical procedures. Newer agents, such as atracurium (Tracrium; Burroughs Wellcome), have a reasonably rapid onset of action for adequate intubating conditions and provide hemodynamic stability.[52] Vecuronium (Norcuron; Organon Pharmaceuticals, West Orange, NJ) can also provide satisfactory muscular relaxation and a short duration of action appropriate for cases lasting 20–30 minutes or longer.[53] Satisfactory conditions for rapid intubation may be accomplished with these agents when the priming principle is used. The priming principle involves the administration of a subparalyzing dose of a nondepolarizing muscle relaxant 3–4 minutes prior to induction and paralysis. A larger dose of the muscle relaxant is then administered with a reduction in the time to neuromuscular blockade for intubation. Succinylcholine, however, is still the muscle relaxant of choice for immediate muscle relaxation and intubation in life-threatening situations.

Regional Anesthesia

Advantages Versus Disadvantages

Regional anesthesia, including epidural and spinal, has been used successfully for laparoscopy but has not gained popularity when compared with general or local anesthetic techniques. Aribarg[54] and Bridenbaugh and Soderstrom[55] have reported the use of epidural anesthesia during laparoscopy. The majority of procedures described in this text are not amenable to regional or local anesthesia. However, for short laparoscopic cases, this type of anesthesia may be considered. Advantages include an awake patient who can give information that may lead to early treatment of complications such as pneumothorax, gas embolism, arrhythmias, and ventilatory insufficiency. Nausea and vomiting occur less frequently than with general anesthesia. Regional anesthesia provides a quiet surgical field and good muscle relaxation. It also provides postoperative pain relief that decreases the need for narcotic analgesics and sedatives. Fewer pharmacologic agents are used, reducing the possibility of allergy, toxicity, and other adverse drug reactions.

Spinal anesthesia may be performed more simply, more quickly, and with less expense than epidural anesthesia. As a complication, however, postdural puncture headache may occur. By using a small-gauge needle (25 or 26) and by limiting spinal anesthesia to older patients (≥65 years of age), the incidence of postspinal headache may be reduced to less than 1%.[56] Because epidural anesthesia is accomplished without dural puncture, the necessity for treatment of spinal headache is minimized. Postspinal headache is a significant complication, particularly in the outpatient setting, where the patient may require an epidural blood patch and/or admission to the hospital for intravenous fluid therapy, analgesics, and supportive care.

Another annoying complication of spinal anesthesia is urinary retention requiring catheterization of the bladder, which often delays discharge from outpatient facilities. Prolonged sympathetic blockade may cause orthostatic hypotension and may also delay discharge. Generally, the patient is free from the risk of orthostatic changes when sensory function has returned.[57]

Disadvantages of regional anesthesia include hypotension, the possibility of failed or inadequate block, systemic local anesthetic toxicity, and the necessity for skillful and well-trained anesthesia personnel. Local anesthetics are given in large volumes for epidural block and may result in seizures, apnea, arrhythmias or cardiovascular collapse. The level of the block must be high enough to eliminate peritoneal discomfort. It is also contraindicated in most pelviscopic surgery because of the need for prolonged pneumoperitoneum at relatively high pressure. In patients with pulmonary disease, the T4–T6 sensory level required may decrease ventilatory function, restrict cough, and increase the possibility of atelectasis. Inadvertent subarachnoid block during epidural anesthesia may lead to a total spinal or cephalad extension of paralysis causing respiratory insufficiency, cardiovascular collapse, and neurologic sequelae. The incidence of both major and minor anesthetic complications is reduced when a skilled and experienced anesthesiology staff is employed.

Regional anesthesia may delay a busy operating schedule when the anesthesiologist does not have the opportunity to initiate the block prior to the surgeon's readiness to start the procedure. Depending on the local anesthetic used, it may take 20–30 minutes for neural blockade after the anesthetic solution has been injected into the epidural space. As a solution to this problem, some facilities provide a separate holding or anesthetic induction room where the patient may receive intravenous fluids and have the block performed with standard monitoring and resuscitation equipment available. This procedure reduces operating room cost and saves time. Recovery from regional anesthesia is slower, however, than recovery from local anesthesia, and the cost for epidural anesthesia, therefore, is not significantly different from that for general anesthesia.[55]

Epidural anesthesia requires intravenous fluid administration of 1.0–1.5 L prior to initiation of anesthesia to prevent hypotension from the loss of sympathetic tone and peripheral vasodilation. Spinal and epidural blocks are contraindicated in the volume-depleted woman suffering from marked dehydration or hemorrhage, as may occur in the postpartum period.

Other contraindications to spinal and epidural anesthesia include a history of neurologic disease, peripheral neuropathy, coagulopathies, infection at the site of needle insertion, previous allergic reaction to local anesthetics, patient's refusal, and an inexperienced anesthesiologist. Prolonged epidural block with 2-chloroprocaine (Nesacaine CE; Astra Pharmaceutical Products, Westboro, MA) has been reported in a patient with plasma cholinesterase deficiency since the drug is metabolized by this enzyme.[58] Orthopedic injuries and conditions of the spine are also relative contraindications to spinal and epidural anesthesia, as back pain is a frequent complication.

Premedication

Patients undergoing gynecologic endoscopy under regional anesthesia require less intravenous sedation and analgesia than do patients receiving general or local anesthesia. Benzodiazepines are commonly used for amnesia and may be given in small incremental doses alone or in combination with narcotics such as morphine or fentanyl. Atropine 0.4–0.6 mg may be given intravenously just prior to incision to minimize bradycardia due to uterine manipulation, or it may be administered intraoperatively for management of vagovagal reflexes.

Technique

Lumbar epidural anesthesia involves the deposition of a local anesthetic solution within the potential space surrounding the lumbar dura and its contents. Various techniques have been described.[54,55,59] The local anesthetic solution may be deposited in the peridural space through the epidural needle once the space is entered and a test dose given. Alternately, a catheter may be threaded through the needle and left in place when the needle is withdrawn to provide a conduit for additional anesthetic administration should the initial dose not provide sufficient analgesia.

The onset and duration of the epidural block is dependent on the local anesthetic and adjuvant agents used. Lidocaine 1.5% is commonly effective in volumes of 20–25 ml.[59] Because of its rapid onset and short duration, 2-chloroprocaine has also been used, particularly for outpatient procedures. Although 2-chloroprocaine produces less systemic toxicity than lidocaine, Nesacaine CE, with its low pH and bisulfite preservative, has been implicated in several cases of neurologic sequelae when inadvertently injected into the subarachnoid space.[58,60–62] A bisulfite-free 2-chloroprocaine solution (Nesacaine MPF) has now been marketed to eliminate this complication. Epinephrine in a 1:200,000 concentration may be added to lidocaine to reduce systemic vascular uptake and resultant toxicity, as well as to prolong the anesthetic block. It is seldom used in gynecologic endoscopy, however, because the prolonged duration of anesthesia with prolonged motor and sympathetic impairment is unsuitable for outpatient anesthesia. Longer-duration agents such as bupivacaine (Marcaine; Winthrop-Breon, New York, NY) are useful for longer pelviscopic surgical procedures.

For spinal anesthesia, hyperbaric lidocaine (Xylocaine; Astra) bupivacaine and tetracaine (Pontocaine; Winthrop-Breon) may be used. Lidocaine, with the most rapid onset and shortest duration, is most appropriate for outpatient procedures, lasting 30–45 minutes. The addition of epinephrine 1:200,000 will provide anesthesia lasting approximately 1.5 times this duration for longer procedures.

Local Anesthesia

Advantages Versus Disadvantages

Local anesthesia with sedation for gynecologic endoscopy is attaining greater acceptance among surgeons and patients, especially in free-standing clinics and ambulatory surgical units. However, this method of anesthesia currently is primarily advocated for diagnostic procedures and sterilizations. Local anesthesia offers maximum safety, minimum physiologic disturbance, and rapid recovery.[31] The incidence of

TABLE 12-4. Commonly used local anesthetics for diagnostic laparoscopy

Drug and drug classification	Route of administration[a]	Dosage form and preparation	Maximum dose (mg)
Esters			
Procaine (Novocain)	I, S	10, 20, 100 mg/ml solution	1000
Chloroprocaine (Nesacaine)	I, N, E	10, 20, 30 mg/ml solution	1000
Tetracaine (Pontocaine)	S	10 and 20 mg/ml solution (Niphanoid crystals)	200
Amides			
Lidocaine (Xylocaine)	I, N, T, S, E	10, 15, 20, 50 mg/ml solution with/without 1:200,000 epinephrine 2.0% jelly, viscous 2.5%, 5.0% ointment	500
Mepivacaine (Carbocaine)	I, N, E	10, 15, 20 mg/ml solution	500
Bupivacaine (Marcaine)	I, N, S, E	2.5, 5.0, 7.5 mg/ml solution with/without 1:200,000 epinephrine	200
Etidocaine (Duranest)	I, N, E	2.5, 5.0, 10.0 mg/ml solution	300

[a] I = local infiltrate; N = peripheral nerve block; T = topical; S = spinal; E = epidural.

serious complications is significantly lowered by the use of local anesthesia, as the majority of untoward events occurring during endoscopic procedures may be related to general anesthesia. Complications related to local anesthesia are far less frequent than those with general anesthesia and are rarely critical.[63] They include excessive sedation and systemic toxicity due to absorption or intravascular injection of local anesthetic agents.

Local anesthesia is most suitable for the cooperative and well-informed patient. The patient with whom communication can be established and who can cooperate adequately for pelvic examination should obtain adequate analgesia with local anesthetic administration and supplemental intravenous sedation.[31]

The importance of preoperative counseling and intraoperative reassurance by confident, considerate, experienced staff cannot be overemphasized. Gynecologic endoscopy under local anesthesia requires smooth, effective teamwork, a minimum of extraneous operating room conversation and activity, and a gentle, precise, skillful surgeon.

The most common operations performed under local anesthesia include sterilization and diagnostic procedures. More extensive procedures require major regional or general anesthesia. Thus local anesthesia is generally unsuitable for pelviscopic surgery because of the length of time required, patient movement, and surgical components (Table 12-4).

Recovery and Discharge

Assessment

Throughout the recovery period, vital signs including pulse, blood pressure, and respirations must be closely monitored. If the patient has received a narcotic antagonist for reversal of narcotic anesthesia or sedation, she should be monitored for 2–3 hours postoperatively to avoid unrecognized renarcotization and respiratory depression.

Recovery following local anesthesia is generally more rapid than with regional or general anesthesia, provided excessive sedation is avoided. Patients are often awake, alert, and ambulatory within 1 hour from the conclusion of surgery. Recovery times for regional and general anesthesia may be expected to be 1 hour 43 minutes and 2 hours 56 minutes, respectively.[56] Various tests have been used to assess psychomotor recovery from anesthetic agents.[64–67] It has been demonstrated that return of psychomotor function following intravenous and inhalational agents may take up to 48 hours.[68]

Outpatient Discharge

All outpatients, regardless of anesthetic technique employed, should be discharged in the company of a responsible adult who will accompany the patient home. Preferably, this adult, as well as the patient, should be informed of postoperative instructions. Travel time to the patient's home should be reasonable. The patient should be warned against operating an automobile or other equipment, taking nonprescribed medications, consuming alcohol, or making important decisions for at least 24–48 hours.[67] If the patient received general anesthesia with intubation, she and her escort should be instructed to watch for signs of stridor related to laryngeal edema. The patient should be given instructions and appropriate telephone numbers in case an emergency arises.

Safety

Monitoring

Monitoring of each patient requires continuous electrocardiography, intermittent blood pressure, and in-line oxygen sensors for general anesthetic equipment. Temperature monitoring should be available, especially in younger individuals, for the diagnosis of hypothermia or malignant hyperthermia. Pulse oximetry is rapidly becoming the most popular instrument for continuous monitoring of capillary oxygen saturation. Capnography, a relatively new method of measuring expired CO_2 levels, is useful for patients receiving general anesthesia with or without controlled ventilation. The capability for blood gas determinations should be readily available in all anesthetizing locations.

Resuscitation Equipment

Pelviscopic surgery and laser laparoscopy involve potential risks, including hemorrhage due to injury to major vessels or bowel, gastric perforation, abdominal wall or visceral hematoma, and pneumothorax.[31,69–77] Gynecologic endoscopy utilizing a Verres needle for insufflation is ideally performed in a hospital or surgical center where emergency laparotomy may be performed under general anesthesia.[31] Therefore resuscitation equipment and trained personnel must be readily available, including a suctioning device, oxygen, defibrillator, emergency pharmacotherapeutic agents, and instruments for airway management. Such equipment should be regularly inspected and maintained.

Laser

Special safety considerations must be observed for laparoscopic laser procedures as presented in Chapter 16. It is of the utmost importance that all personnel in the operating room be equipped with protective eyewear, preferably with side shields when the CO_2 laser is in use. The patient's eyes must also be protected by either protective glasses or goggles or by moistened eye pads during general anesthesia.

Outpatient Laparoscopy

The desire for a low-cost, efficient setting for gynecologic surgical procedures will continue to increase the number of patients undergoing gynecologic endoscopy as an outpatient procedure. The safety and acceptability of outpatient sterilization has been well documented. Most patients presenting for endoscopy are potential candidates for outpatient anesthesia and surgery. Ambulatory surgical centers routinely admit young, healthy individuals, ASA Class I (American Society of Anesthesiologists classification) and patients with minor systemic conditions (ASA II). In many centers, patients who have stable chronic illnesses (ASA III) may be considered for outpatient surgery, in consultation with the anesthesiologist. These patients must be capable and willing to comply with routine instructions for fasting, medication, discharge, and postoperative care.

Patients in whom complications may be expected should be admitted to the hospital the evening prior to or the morning of surgery. These patients include any patient with ASA II or III disease or medication requirements that preclude ambulatory anesthesia or surgery. Obese patients, those with a history of previous peritonitis, those suspected of having significant pelvic adhesions or ectopic pregnancy, or any other patient suspected of requiring laparotomy should be treated in a facility that has close access to a hospital in the event postoperative hospitalization becomes necessary.

Summary

In no other gynecologic procedure is an understanding of physiologic alterations and anesthetic requirements more important than for gynecologic endoscopy. The outpatient setting, requirements for pneumoperitoneum, electrical systems, and application of laser technology increase the hazards and potential for complications associated with endoscopic surgical procedures. The requirements for safe, judicious patient management create interdependence between the surgeon and the anesthesiologist. Both must be knowledgeable and experienced in routine and emergency preparation and procedures in the patient undergoing pelviscopic surgery or laser laparoscopy.

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13
Operating Room Personnel

CAROLYN J. MACKETY

The evolution of new surgical techniques, including minimally invasive procedures, has shifted the services rendered to patients from the inpatient to the outpatient setting. These procedures are performed on young healthy adults as well as a larger older population that may be at higher risk for conventional surgical procedures. These older patients have fears and other cultural expectations of the surgical experience. Therefore it is paramount that the nurse and other operating room (OR) personnel establish a collaborative practice with the physician so she or he may assist the patient in developing an understanding of the risks and expected outcomes of the operative procedure.[1]

Nursing is defined as the diagnosis and treatment of human responses to actual or potential health problems.[2] Nurses apply this process in a systematic way using groups of signs and symptoms. Nursing intervention is directed toward the patient's progress to health recovery. During the preoperative assessment, the patient has the opportunity to verbalize concerns about her disease process and treatment modality. Many women may be concerned about the cosmetic results of surgery, uneasy about the time spent in physical rehabilitation, and anxious about physical functional impairment and a prolonged return to well-being. Health care professionals must become proficient in developing creative methods of patient assessment to accumulate the necessary data to enhance the development of perioperative care.

Although the perioperative role has been defined for the operating room nurse, in today's medicine she or he becomes a part of the team that uses all the elements of the nursing process in planning the total care of the patient. The nurse clinician who is responsible for endoscopy and adjunctive systems should have the knowledge to discuss the risks and outcomes with the patient and her family and to participate in planning perioperative care.

The nurse who has this responsibility must have additional education to understand the ramifications of new equipment and technology of certain operative procedures. Education is an essential component to quality assurance and the prevention of any associated risks to the patient. Several American companies have entered the endoscopic market with new and improved laparoscopic equipment. Most provide in-depth inservice training for the nursing staff on assembling the equipment and the care and cleaning of all the components. It should be scheduled on a regular basis, depending on the turnover of personnel in the department. The laser is also a unique instrument, and the staff may be required to learn the operational characteristics of more than one laser system.

Training of laser support personnel should include didactic and clinical components

(Table 13-1). The education process should include laser biophysics, tissue interaction of the wavelengths to be used, specific laser safety issues as applied to each wavelength, and those surgical indications where the laser will be used. The clinical component includes all operational characteristics of each laser system, trouble-shooting information, and training as to how all the various laser accessories attach to the lasers and any other variation that may be required for successful operation of the equipment. Performance criteria should be developed, the learning experience documented, and competence evaluated.

The nurse in collaborative practice with the physician performs duties that include all the elements of the nursing process—assessment, planning, implementation, and evaluation. Preoperative assessment begins when the patient presents with a perceived medical problem. A complete history and physical may have an impact on the outcome of the procedure, as other organ system problems may affect the results of the care rendered.[3] The nurse must always take an in-depth drug history not only for allergies but to anticipate any potential anesthetic problem, such as hypokalemia due to chronic intake of diuretics. If the patient does not know what medications she is taking, the pharmacist can be contacted and a medication profile obtained, or the medication can be presented to the hospital pharmacist for identification. Nutritional status is important for wound healing and, when adequate, will often decrease surgical morbidity. A physical examination with appro-

TABLE 13-1. Job Description

Title: Clinical Laser Nurse

Reports to: Laser Program Coordinator

General summary: Responsible for coordinating all laser procedures in the facility and evaluating the care given to the laser patients. Works in a collaborative environment with the related departments where laser procedures are done: surgery, endoscopy, outpatient, etc. Establishes collaborative working relationship with the physicians using the lasers in their daily practice, assessing their needs for further education, equipment, and supplies. Assists in the continuing education process of the physicians and nurses at the hospital. Responsive to the community needs for information regarding the laser program and center.

Principal duties and responsibilities

1. Supports the established and approved policies and procedures for the laser program.
   a. Assists in the scheduling of the lasers used in the facility, avoiding conflicts inter- and intradepartmentally.
   b. Assists the Laser Safety Officer in maintaining a laser safe environment wherever the lasers are placed in the facility.
   c. Evaluates the delivery of care given to the patients having laser procedures.
   d. Assists in the development of discharge planning for patients having laser procedures.
   e. Assists in the development of patient and family laser education information.
   f. Does preoperative assessment of patients having laser procedures, as needed.
   g. Does postoperative assessment and evaluation and maintains a log of information concerning the patients having laser procedures.
   h. Assists in identifying laser-related accessories, equipment, and supplies and makes sure they are ordered as necessary.
   i. Assists in the development of quality assurance criteria for patients having laser procedures.
   j. Speaks to community groups as needed.
   k. Participates in physician and nursing educational programs.
   l. May participate in laser research projects.
   m. Assists with referral phone calls to prospective patients for the laser center.
   n. Documents the laser log or nursing notes for the laser procedure.
   o. Serves on selected hospital committees as requested.
   p. Performs any other duties as assigned or deemed necessary by the Laser Program Coordinator.

Knowledge, skills, and abilities required

1. Registered Nurse with a current license to practice in the state.
2. Two to three years of operating room experience.
3. Training to use laser system desirable but not required.
4. Demonstrates physical, mental and emotional stability to work in a stressful environment.
5. Demonstrates good verbal and written communication skills.
6. Demonstrates the ability to work as a team.
7. Have knowledge of community resources as they relate to the laser center.
8. Have the ability to do public speaking.
9. Be able to take call as necessary for emergency procedures that may need laser usage.

priate diagnostic tests is completed before admission and should be on the chart prior to surgery. As discussed previously, the patient's fears and anxieties should be verbalized, and she and her family should have an understanding of the risks and expected outcomes of the operative procedure.

As there is much information in the public domain regarding new procedures and techniques that may influence the patient's understanding of the proposed plan for treatment, it will be important to obtain informed consent. Informed consent requires adequate disclosure of the risks and alternative methods of treatment and will minimize liability. Good documentation of this communication is necessary, but the process of informed consent is more important than the consent form itself (see Chap. 21).

Interoperative care includes good planning. The surgical indications must be understood clearly by all OR personnel and the care plan implemented for the expected outcome of the procedure. The nurse is responsible for quality, safe care. To prepare, she or he must understand and anticipate all of the physician's needs and assume the role of the patient's advocate. The nurse must know if the physician has privileges to use the special equipment for the procedure selected: Argon, KTP, Nd:YAG, or CO_2 lasers may be used for pelviscopic surgery, depending upon the abnormality (Table 13-2).

Assembling and ensuring the sterility of the pelviscopic surgical instruments is the nurse's responsibility. The instruments may be sterilized with ethylene oxide or soaked with an activated dialdehyde for 10 minutes. The instruments must be cleaned and disassembled before sterilization regardless of what method is used. If video equipment is used, the camera is sterilized according to the manufacturer's recommendations. As with all endoscopic equipment that is soaked in an activated dialdehyde solution, careful rinsing is essential. The instruments with lenses should be rinsed with warm water to prevent fogging.

If a laser is to be used with the laparoscopic instruments, there are additional responsibilities that must be considered for each laser wavelength. When the CO_2 laser is used, the coupler cube must be washed carefully in warm soapy water and the lens cleaned with "absolute alcohol" and polished with lens paper. The coupler cube is *never* steam-sterilized, as this process will decrease the transmission of the laser beam by interrupting the integrity of the special optical coating. If it occurs, there may also be beam divergence through the scope (Tables 13-3 and 13-4). The argon, KTP, and Nd:YAG lasers use a fiber delivery system. Depending on which wavelength is chosen, fibers will need to be inspected for their integrity and to ensure that they are highly

TABLE 13-2. Laser set-up/shut-down

Objectives: To describe the procedure, document the preprocedure function, and ensure that the laser is operational for the next usage.

Procedure: The start-up/shut-down checklist is followed.

CO_2 checklist
YAG checklist
KTP checklist

TABLE 13-3. CO_2 start-up/shut-down procedure

( ) Hang appropriate warning signs on the doors and make eye protection available.
( ) Provide appropriate fire extinguishing materials.
( ) Plug laser in.
( ) Attach desired accessory to articulating arm.
( ) Turn key to operate.
( ) Check the laser for faults. If a fault occurs, turn laser off and notify Laser Safety Officer.

If laser is functional

( ) Check for red helium neon (HeNe) aiming beam to increase or decrease intensity, rotate knob located on laser head.
( ) Select mode—*For testing use CW mode.*

To test

( ) Press increase/decrease to set desired wattage. For testing, select 10 watts at 0.1 second.
( ) Test fire at tongue blade on wet towel. Check alignment to see if the burn occurs in aiming beam.
( ) If you will be staying with the machine, press the standby button; otherwise, turn the key switch off and remove the keys.

TABLE 13-4. CO_2 checklist: laser nurse responsibilities

Yes	No	
Environmental Safety		
( )	( )	Hang danger signs on all doors.
( )	( )	Have basin of saline available.
( )	( )	Move laser and accessories into room.
( )	( )	Protect patient's eyes with wet eyepads, moistened periodically.
( )	( )	Make sure proper endotracheal tube is used.
( )	( )	After prepping, make sure area is wiped absolutely dry.
( )	( )	Make sure appropriately wet draping is used (have extra draping available).
( )	( )	Use nonreflective instruments.
( )	( )	Use titanium or quartz rods for laparoscopic work.
( )	( )	Use smoke evacuator or in-line suction.
( )	( )	Only laser-trained personnel operate the laser, and they do not leave during operation unless relieved by trained laser personnel.
( )	( )	Only the physician operates the foot pedal.
Laser Safety		
( )	( )	Provide safety glasses available for staff, physician, and patient.
( )	( )	Move laser to patient.
( )	( )	Attach laser accessories.
( )	( )	Drape laser properly when applicable.
( )	( )	Position foot pedal near physican's foot.
( )	( )	Use wet sponges to protect surrounding tissue.
Start-up		
( )	( )	Turn on laser.
( )	( )	Select desired mode and wattage.
( )	( )	Place laser in stand-by mode when not in use.
( )	( )	During surgery, periodically check gas gauge for sufficient amounts.
Shut-down		
( )	( )	Turn laser key to off position.
( )	( )	Place articulated arm in holder.
( )	( )	Move laser away from patient.
( )	( )	Unplug laser and secure cord.
( )	( )	Turn off tanks.
( )	( )	Remove and clean accessories and return to storage.
( )	( )	Collect eye protection and return to storage.
( )	( )	Wipe off laser and foot switch and return to storage.
( )	( )	Place key in proper location.
( )	( )	Record procedure in laser log book.

If the laser malfunctions or unsafe practice occurs, complete an "incident and malfunction report" and "variance report" and present it to the laser safety officer.

If malfunction occurs, call biolaser engineer.

polished. In the contact YAG procedure, the fibers are disposable, but the tips will need to be inspected and cleaned for continued use[2] (Table 13-5).

With the KTP laser, most of the routine maintenance will be done by the biomedical technician provided by the company or a technician who has been trained in the hospital. The nurse will be responsible for maintaining the coolant at the proper level in the reservoir using deionized water only (Table 13-6). It should be checked every few weeks and more frequently if the laser is in

TABLE 13-5. Nd:YAG set-up/shut-down procedure

Yes	No	
( )	( )	Obtain laser key.
( )	( )	Set up room for procedure. Position laser in accessible location. Have available all accessories. Post warning signs on all doors. Cover all windows. Obtain any requested equipment.
( )	( )	Provide protective eyewear for all individuals in the room when performing a nonendoscopic procedure.
( )	( )	Plug laser into 220 watt single phase outlet or 208 watt triple phase outlet (depending on manufacturer).
( )	( )	Turn laser key on. (If laser has not been used in several days, it may take 20 minutes to warm up.)
( )	( )	After warm-up, follow directions on the front panel display.
( )	( )	Insert cartridge.
( )	( )	Set up fiber with contact probe.
( )	( )	Follow instructions on display screen to calibrate the laser. (Recalibration should take place if the laser is turned off or the fiber is replaced.)
( )	( )	Select Pulse Mode or Continuous Mode.
( )	( )	Select Fluid or Air Delivery.
( )	( )	Press *Ready*—laser is now activated.
( )	( )	Place machine on *Standby* when not in use and until the operator is ready to use the laser.
( )	( )	Press status button to document energy used.
( )	( )	Press *Stop* to turn off laser.

Note: To use the manual mode, turn the knob adjacent to the calibration knob to the right. Fire the laser into the calibration port to determine output power.

TABLE 13-6. KTP-532 LASERSCOPE laser checklist

Yes	No	
( )	( )	Hook-up water lines, turn on water, check output pressure, check for any possible leaks around fittings.
( )	( )	Plug laser system in and turn on circuit breaker.
( )	( )	Turn start key clockwise to ON position and wait for warm-up cycle to finish.
( )	( )	Hang "warning signs" on doors, cover operating room (OR) windows, and provide safety glasses for OR staff, physicians, and patient, if necessary.
( )	( )	Choose proper type of delivery device for specific procedure.
( )	( )	Calibrate device in calibration pod; if using endostat and fiber, cleave fiber and check aiming beam for nice round spot. *Note:* When calibrating you always look for the highest transmission percentage possible!
( )	( )	After you have obtained the best transmission, set output wattage and time settings according to the physician's preference.
( )	( )	Be certain when using the endostat or microbeam that eye safety filters are in place.
( )	( )	When case is completed turn key to "Off" position and shut off circuit breaker.
( )	( )	Turn water valve off and disconnect lines over bucket, then drain off hoses into bucket; attach input and output of water line together.
( )	( )	Coil up lines: first water hoses, then electrical cords.
( )	( )	Be certain all laser accessories, i.e., micro beam, endostat fibers, warning signs, safety glasses, and calibration instruments, are properly stored before moving the laser.

Note: Any faults that appear may be corrected by referring to the laser manual; if a problem persists, call laser technician!

constant use. Never immerse the connector on the main fiberoptic cable or optic coupler in any fluid. The connectors are gently wiped off with an alcohol-damp swab, avoiding the lenses and windows. The optical components are cleaned with reagent quality acetone and methanol (in that order), or methanol alone, and dried with lens tissue. The quartz fiber delivery system with connector may be gas-sterilized only. This system must not be immersed in any fluid or steam-sterilized. The fiber cleaving procedure will be taught by the company representative. Care of the micromanipulator is a nursing function; the instrument should be wiped with a soft cloth that has been slightly dampened with a mild antibacterial solution. The mirror and large lens are cleaned with reagent grade acetone and dried with lens tissue.

The argon laser may be used in laser laparoscopic surgery. The care and cleaning of the accessories for this laser are similar to that for the KTP and YAG lasers. There are two types of YAG procedure: noncontact methods using bare quartz fibers, and contact methods that use a fiber with a synthetic sapphire probe attached to a delivery system, either a fiber or a handpiece (see Chap. 20). The maintenance of the laser system is the responsibility of the biomedical department or technician assigned to the laser program. Nursing responsibilities include maintaining the quartz fibers as well as cleaving, polishing, and sterilizing them, selecting the appropriate disposable fiber or handpiece, and selecting the correct contact tip for the contact method.

All laser systems are maintained for cleanliness in the same manner as other equipment used in a sterile environment. Also, all laser accessories, such as laparoscopes, hysteroscopes, pelviscopes, microscopes, micromanipulators, fibers, and other related accessories, are cared for according to the manufacturer's recommendations.

Laser safety is covered in Chapter 16 and is another important responsibility for the clinical nurse. Each wavelength requires some variation in the safety protocols. Eye protection for the physician, staff, and patient must be considered. Each laser requires eyewear of the correct optical density that should be worn during all laser procedures. There are several manufacturers, and many offer either specific optical density or multiwavelength optical densities for eyewear. The nurse should make sure the optical density is specific for the laser that is to be used. When working with endoscopes, there are special attenuators that fit over the eyepieces of the scope so that physicians need not wear glasses during the procedure.

The patient's eyes will also need protection. If a local anesthetic is used, the patient should wear the appropriate eye protection. If the procedure is done under general anesthesia, the patient's eyes should be closed (taped). When using the CO_2 laser, moist pads should cover the eyes. When the transmittable wavelengths are used during Nd:YAG, argon, or KTP laser treatment, a folded towel is used to cover the eyes, as the moist eyepads will not stop the transmission of the laser beam.

It is recommended that all personnel who will be working with lasers should have a baseline eye examination to include visual acuity as well as funduscopic examination. It should be documented and a copy of this examination put in the personnel file. If and when the employee leaves the facility, it is recommended that an exit eye examination be performed to protect against a workman's compensation claim.

Other essential safety procedures are those that describe the "Controlled Area" where the laser is being used. Signs should be posted that describe the type of laser being used and what eyewear is required upon entry into the room. If the laser is used where there is public access, a locking mechanism should be installed to prevent inadvertent admission to the area. For the transmittable wavelengths, the viewing windows should be covered using industrial grade window shades.

The use of flammable preparatory solutions are avoided as an intraoperative safety precaution. If they are necessary, make sure the prepped area has been dried with a sterile towel. Plastic surgical incise drapes are not to be used during laser procedures as they are highly flammable. Water should be available during the procedure to extinguish any flame-up that may occur. If a potential hazard is observed, the laser should be put in a standby mode until the situation has been rectified. When moving any laser equipment, one must be careful not to bump the systems, as the mirrors may go out of alignment. If the lasers are moved frequently, alignment must be checked prior to each procedure.

Laser plume should be evacuated during the endoscopic procedure, and there are several methods for its removal. The CO_2 laser generates increased amounts of laser plume so it is difficult to see in the pelvic space. An in-line plume valve can evacuate the smoke as the physician requests. The argon, KTP, and YAG lasers create less laser plume, although it must also be evacuated using the same methods.

A trouble-shooting procedure should be developed along with start-up and shutdown checklists; they make sure that there is an available working laser system. The Joint Commission on the Accreditation for Hospitals assesses preventive maintenance, quality assurance, education for nurses and physicians, and documentation of laser procedures. These policies and procedures should be developed by a committee that has monitoring responsibilities for the laser program (see Chap. 16, section on laser safety).

Documentation is a nursing responsibility that can be performed in a laser log or in the nurse's notes. The physician dictates the operative notes in the usual fashion.

Postoperative care for patients who have undergone laparoscopic procedures, with or without the laser, is not essentially different than for "conventional" procedures. If the procedure is performed under general anesthesia, the patient arrives in the recovery room to emerge from the anesthetic. Vital signs are assessed, and the patient is observed for fluid overload, which may result from the increased volumes of irrigation fluid used during the procedure. The CO_2 gas used to produce the pneumoperitoneum distends the abdomen, causing pain or discomfort between the shoulder blades from phrenic nerve irritation while in the Trendelenberg position. This discomfort may continue, as the gas takes approximately 24 hours to dissipate from the body. The abdomen is checked for increased girth, which may indicate intraabdominal bleeding. Pelvic pain that does not abate with analgesia may indicate bowel perforation. Depending on the procedure performed, the integrity of the pelvic organs, such as bowel, bladder, and ureter, may be compromised. The optimal goal of postoperative care is to return the patient to normal physiologic balance and wellness.

Depending on the procedures, operative laparoscopy or pelviscopic surgery can be performed on an outpatient basis.[4] Discharge instructions are given in the outpatient discharge unit. It is best to have a responsible family member accompany the patient so that instructions are given in their presence and are understood and interpreted correctly. A copy of the instructions should be given to the patient when she is discharged. Discharge instructions may include a prescription for an oral analgesic and what types of activity are permitted or when they can be resumed. Patients who have pelviscopic surgery are instructed to sit or assume a semi-Fowler's position to minimize postoperative discomfort. Outpatients having general anesthesia should be instructed not to operate a vehicle or make important decisions for at least 24 hours postoperatively. Alcoholic beverages should also be avoided. If the patient experiences excessive pain, bleeding, or elevated temperature (greater than 100°F on two consecutive occasions less than 24 hours after surgery) the physician should be called immediately. If the patient remains on a short-stay unit or is admitted to the hospital, specific postoperative instructions will be written by the physician.

Follow-up phone calls are made to those patients discharged early to assess their progress toward wellness. The patients are usually instructed to return to the physician's office within 1–4 weeks for continued evaluation.

Special considerations for continued care may have to be given if the patient is in the older age group. Health maintenance education may need to be emphasized, and consultation with a home health agency may be needed for assistance toward self-care. The nurse will need to establish who the primary care-provider will be and that person's ability to continue appropriate care when the patient is discharged. This type of health care delivery may have considerable impact on the patient's fears and anxieties in coping with the activities of daily living. The older patient may require additional knowledge in preventive maintenance or treatment regimens. It is the responsibility of the nurse to be aware of the community resources available for continued care for these patients.

In summary, the patient who is to undergo operative laparoscopy with or without the addition of a laser needs specific nursing care that must be understood in a perioperative setting. Laparoscopic surgery, like other endoscopic procedures, reduces the time in the operating room and is minimally invasive so the patient spends less time in the hospital. Operative laparoscopy is also associated with a faster recovery period as there is little or no bleeding and postoperative discomfort is minimized because there is decreased inflammatory tissue response. Nurses are accountable for the return of their patient to optimal health on a continuum toward wellness.

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14
Laser Biophysics and Principles of Control

GREGORY T. ABSTEN

In every area of human endeavor, technology has opened the door for new advancements. Medicine is no exception. Laser technology is contributing to a broad and rapid expansion of both diagnostic and treatment procedures.

Quantum physics has brought us to the subatomic realm allowing us to tap the very forces that hold matter together. In this same manner, the laser is not simply another step along a continuum of electronics but an evolution to a higher level. This chapter reviews the basics of laser characteristics, delivery, and control so as to provide a basic foundation for practical techniques of laser surgery and to keep pace with future developments.

Lasers are devices that produce intense beams of light energy. They convert electricity to light, which can be further intensified and applied directly to medicine to cut, vaporize, or coagulate tissue. Various materials emit characteristic colors of light. These materials are used as the lasing medium that gives the laser its particular name, such as argon or carbon dioxide (CO_2).

Laser is an acronym that stands for

*L*ight
*A*mplification by the
*S*timulated
*E*mission of
*R*adiation.

It refers to the process by which the light waves are generated and amplified, not simply to a device. The key mechanism of action is stimulated emission of radiation, first described by Albert Einstein in the early 1900s.[1] In the late 1950s Arthur Schawlow and Charles Townes[2] proposed the first practical laser based on Einstein's theories. Theodore Maimon[3] then constructed the first ruby laser in 1960. Lasers were used experimentally in medicine almost immediately. Much of the credit for overall progress in medicine must go to Leon Goldman[4] of San Diego, California, for his foresight and continued perseverance to enhance this transition.

Although the exact nature of light is still not understood, it exhibits characteristics of both discrete particles (photons) and waves. To understand the electromagnetic spectrum and lasers, we will primarily discuss light in terms of wave characteristics: wavelength (color), amplitude, velocity, and frequency.

Properties of Waves

Wavelength

The wavelength is the distance between two successive crests or any other two points on the same parts of the wave. The color of visible light is determined by its wavelength, which is measured in fractions of a meter, known as nanometers (nm). One nanometer is equal to 10^{-9} meter. Our eyes are designed to see only a small portion of the spectrum. Visible light waves have wavelengths in the range of about 385–760 nm (Fig. 14-1). More energy is associated with short wavelengths (blues) than with long wavelengths (reds).

Amplitude

The amplitude is the height of the wave with maximum displacement from the zero position. Like an ocean wave, the greater the amplitude the more power there is, and, in the case of light, the brighter the beam.

Velocity

The velocity of waves is a constant in a given medium and is equal to about 186,000 miles/second, or about 300,000 km/second, in a vacuum. The unique characteristic of light is that the speed is constant in all frames of reference. In this sense its speed is an absolute and is further explained in Einstein's theory of relativity.

Frequency

The frequency is the number of waves passing a given point per second and is expressed in cycles per second, or hertz (Hz). The shorter the wavelength, the higher the frequency, as more waves will be able to pass a given point in a certain time.

Phase

Some further properties of waves also need to be considered. Waves (of the same wavelength) are "in phase" when all the troughs and all the peaks are opposite each other. If two such waves meet, the result is a reinforced wave of double the amplitude (increased brightness). Conversely, if the waves are "out of phase" (troughs opposite peaks), the result is a disappearance of the wave (Fig. 14-2). This subject is discussed more as coherence.

Having considered some of the fundamental properties of light waves, we are now in a position to understand how a laser works, where its light comes from, and how this light differs fundamentally from ordinary light.

Emission of Light

In an atom, electrons occupy certain discrete energy levels, or orbits. These electrons are not free to exist at energies between levels or to occupy positions between orbits, so that when the energy level of an atom is changed the electrons must move up or down to the next orbital level. When an atom or molecule absorbs energy, electrons move into higher orbits but fall back to their own less energetic resting orbits almost immediately,

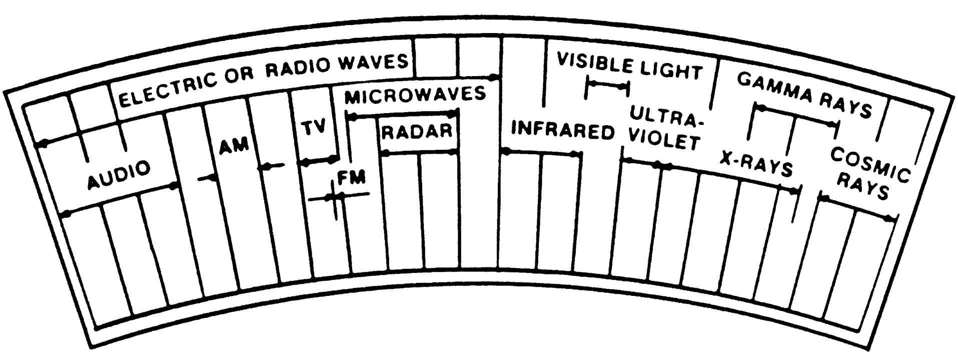

FIGURE 14-1. Electromagnetic wavelengths. (From Absten GT: Fundamentals of Laser Surgery, copyright © 1985.)

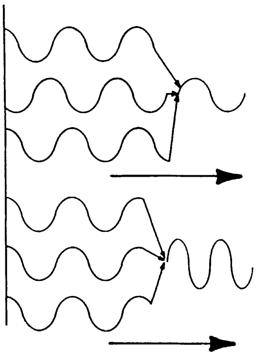

FIGURE 14-2. Wave showing the property of coherence. (From Absten GT: Fundamentals of Laser Surgery, copyright © 1985.)

sometimes getting stuck for just an instant at an intermediate level. When an electron falls to a lower energy level, a tiny burst of surplus energy escapes. In the case of lasers, this energy is known as a photon, the basic unit of light. Energy determines the wavelength, which is the color of the light.

When many atoms in a medium undergo spontaneous orbital decay, the process is known as "spontaneous emission." The decay of different atoms occurs at random. Many energy levels are involved, and the light is emitted out of phase and in different directions. Different energy levels result in multiple colors of light. All of the colors combined produce white light. Spontaneous emission produces incoherent light. Like taking the lid off a popcorn popper just as all the kernels begin to explode, the "kernels" of light travel in all different directions out of phase with one another.

As previously stated, lasers are usually named for their lasing medium. A substance has the potential to become a lasing medium if it can have more atoms or molecules in a high energy state than in its resting energy state. This process is known as a "population inversion." Different mediums emit characteristic colors of light, which, in turn, are used for various medical applications. The surgical effects of most lasers are due to localized heating when the light is absorbed by tissue. As tissue begins to heat, it first blanches white as it is coagulated, shrivels as it is desiccated, and finally turns to steam and vapor as it is vaporized above 100°C. These circumstances will be examined in more detail later in the chapter.

In most lasers, a medium of gas, liquid, or crystal is energized (pumped) by a suitable source (light, electric discharge, radiofrequency). This energizing, or excitation, raises the electrons in greater numbers of atoms to higher energy levels more rapidly than spontaneous decay can return them to their original level. Once there is a preponderance of these excited atoms (i.e., atoms having an electron in a higher energy level), a further process becomes probable in addition to the spontaneous emission just described. A photon from an initial spontaneous decay stimulates each excited atom in its path to emit an identical photon, in phase, of the same color and traveling the same direction. These photons actually fuse together in time and space producing a coherent output. This process is known as "stimulated emission"—each photon stimulating another energized electron to produce a further photon, until a photon cascade of growing energy sweeps through the medium like a chain of dominoes falling (Fig. 14-3). It is an internal electronic process within the atom rather than the "hot body" process of ordinary light emission.

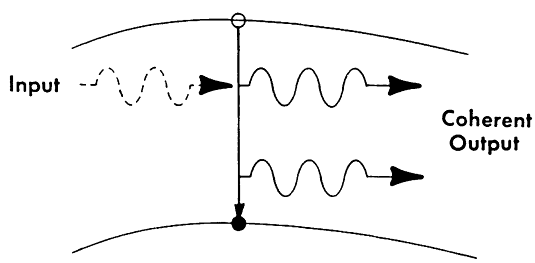

FIGURE 14-3. Stimulated emission. Each photon stimulates another energized electron. (From Absten GT: Fundamentals of Laser Surgery, copyright © 1985.)

The waves of light produced in this way are reflected back and forth many times by mirrors at each end of the laser chamber. These mirrors perfectly face each other and form a type of "infinity tunnel" in which the light waves are trapped and bounce back and forth at the speed of light, increasing the amplitude (power or brightness) of the wave with each pass. In medical laser systems one of these mirrors is partially transmissive (like a two-way mirror), which allows the laser beam to "leak out" at one end forming the beam of laser light.

The laser beam is passed through a delivery system to the surgical field. Fibers or articulated arms deliver the beam, and lenses or sapphire probes focus and intensify the energy. The various attachments and delivery systems determine the utility of any laser.

Special Properties of Laser Light

Laser light differs from ordinary light in much the same way that music differs from noise. Three particular properties are responsible for this difference: coherence, collimation, and monochromaticity.

Coherence

Coherent light consists of unbroken waves that are of constant wavelength and have no phase differences either in time or space (temporal and spatial coherence). An analogy may be drawn between a pure musical note (coherent) and discordant noise (incoherent).

Ordinary light, from a lamp or fire, is "incoherent" and consists of light waves radiating (shining) in all directions out of phase with one another. Because multiple wavelengths (colors) are produced, it is impossible for phasing to occur. The action of this incoherent light is similar to the wave patterns that are produced when a handful of stones are thrown into a pool of water; the choppy wave pattern it creates on the surface is "incoherent" because the ripples produced by each individual stone are out of phase with one another. Laser light is "coherent". The light is also of one wavelength (color), which allows the waves to "synchronize" when they are phased together. When a piano tuner strikes a tuning fork, he phases the piano string to the tuning fork. The surf breaking onto the beach is also a phased wave pattern. When the peaks and troughs align, they are in phase.

Collimation

The light of a collimated beam is parallel and does not diverge, in contrast to the light from a flashlight, which will spread out as it travels further and further away (Fig. 14-4). Laser light is practically parallel, so that a laser pulse fired at the moon produces a spot one-half mile wide at a distance of 240,000 miles. For practical everyday purposes this spread is insignificant. For medicine this collimation of light is significant for two reasons: There is a minimum loss of power along the beam, and it can be focused to intensify its effect or couple it into a slender single fiber. This intensification means that a laser beam can be a billion times brighter than sunlight.

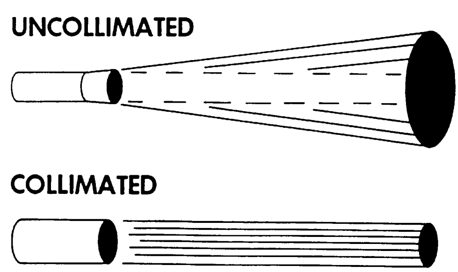

FIGURE 14-4. Collimated beams of light are almost parallel, in contrast to the uncollimated light, as from a flashlight, which spreads out as it travels. (From Absten GT: Fundamentals of Laser Surgery, copyright © 1985.)

Monochromaticity

Monochromaticity indicates that the light is all of the same wavelength (color). Ordinary light sources, like the glowing filament in a lamp, usually consist of a mixture of all possible colors in a broad range resulting in white light. All the light of the laser is concentrated in a few, frequently one, discrete wavelengths. Lasers produce pure colors of light.

Laser Medium

A laser is usually named after its active medium—the substance that exhibits the lasing action. There are three basic mediums: liquid, solid, or gas material. Substances that have been used include the following.

1. *Liquids*: dyes of various types that allow emission of various wavelengths depending on the dye, giving rise to the name "tunable dye" laser
2. *Solids*: (almost always a crystal) ruby; yttrium aluminum garnet (Nd:YAG), treated with neodymium, a rare earth element; Nd:glass, erbium YAG (Er:YAG); holmium YAG, alexandrite, gadolinium aluminum scandium garnet treated with neodymium (Nd:GASG).
3. *Gases*: carbon dioxide, argon, krypton, helium-neon, carbon monoxide, hydrogen fluoride, argon fluoride, xenon chloride

Other substances have also been used, but the lasers that have found the widest applications in medicine at the moment are those based on carbon dioxide, argon, Nd:YAG, krypton, and various dyes. All these substances must be energized to excite the electrons into a state of population inversion. Solid and liquid lasers tend to be energized optically, usually by flash lamps or another laser; and gas lasers tend to be energized electrically by direct current or radiofrequency.

Sealed Tube Lasers

When the carbon dioxide gas mixture is energized and stimulated to emit its light, there is a disassociation of the molecule into carbon monoxide and a free oxygen radical, unlike argon or neodymium atoms, which do not break apart (Fig. 14-5). The resulting molecule is no longer able to produce light. Complicating this arrangement is the fact that the electrodes in the laser tube further degrade the gas mixture. In medicine, three basic configurations of carbon dioxide lasers have resulted. Understanding these concepts will be helpful when choosing laser systems.

Flowing Gas Systems

Because of the disassociation of the molecule and electrode contamination, a flowing gas system is used to purge the tube and replenish the gas. It requires cylinders of replacement gas, pressure regulators, and a vacuum pump to draw the gas through the system, all of which add to the maintenance, noise, and expense of operating the laser. On the other hand, flowing gas systems produce

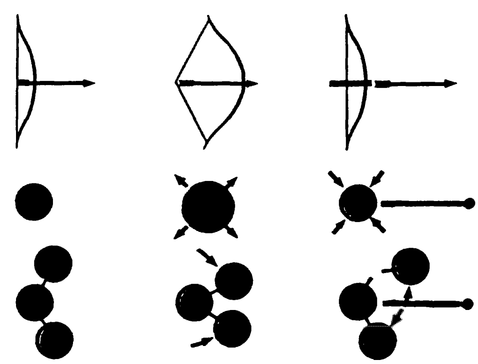

FIGURE 14-5. Disassociation of the molecule of CO_2 gas after it is energized and stimulated to emit light. It results in a carbon monoxide molecule and a free oxygen radical. (From Absten GT: Fundamentals of Laser Surgery, copyright © 1985.)

a reliable, steady output and generate high powers (20–100 watts) for medical use.

Free Space, Sealed Tube Lasers

The sealed tube lasers are a newer generation laser tube that eliminates the need for replacement laser gas mixture, regulators, and vacuum pumps. They produce power levels comparable to flowing gas systems (up to about 100 watts).

Direct current (DC) excitation, is used in the DC excited sealed tube laser and the flowing gas systems. The electrodes are specially treated, and catalysts and inhibitors are added to the self-contained gas mixture to retard breakdown of the gas, which allows for a sealed tube type of laser system. After several thousand hours of operation the tubes will need to be recharged as the power begins to gradually fall from the high end.

Radiofrequency Waveguides

Radiofrequency waveguides are also sealed tube systems that use a radiofrequency transmitted transversely across the tube to excite the gas molecules. The ceramic tube of the laser is also impregnated with catalysts and inhibitors to retard breakdown of the gas. The radiofrequency is contained within a "waveguide" structure of the laser. There is no associated interference with monitors or electrical equipment from most of these medical systems. Radiofrequency (RF) waveguide lasers have historically produced low power (25 watts and less), though newer systems produce outputs of up to 55 watts.

Sealed tube systems of both varieties (DC excited or RF waveguide) are generally simpler to operate, quieter, and require less routine maintenance than flowing gas systems.

Control Parameters

Several parameters control the delivery of laser energy to tissue, including the power (watts), total energy delivered (watts and time), power density (the size of the focused spot in relation to the watts used), the color of the light, and the color and vascularity of the tissue. It is important that surgeons attend good hands-on training programs or work extensively with lasers during their residency to learn control of these parameters.

In some ways these energy concepts are intuitive. The use of the laser beam is analogous to the use of a magnifying glass to focus sunlight and create a burn. The brighter the sun (power), the more it burns. The smaller the spot created with the lens (power density), the "hotter" it burns. The longer the sun is focused in one place (total energy), the more extensively it burns. The wetter the target you are trying to burn (vascularity), the longer it takes to create the same effect.

The surgeon has control over a combination of three parameters: power, length of time, and spot size. The power of the laser is set at the machine by the laser specialist operating the unit. Some lasers have remote control panels to allow use in the sterile field.

The second parameter is the time of application. The laser can be used in a continuous mode, in which case the time of application in any one spot is determined by how the surgeon moves the beam. In this mode the beam is emitted so long as the foot pedal is depressed. The laser may also be used in a timed pulsed mode to make application of the beam brief, usually in fractions of a second, to limit the spread of heat. A timed pulse gives the surgeon more control, reaction time, and less spread of heat damage. However, it is a much slower process than with the continuous mode. The timed pulse may also be set at the control console of the laser.

The third parameter for the surgeon to control is the spot size of the beam. The spot size is controlled directly by the surgeon in the operative field and depends on the delivery device being used. For the CO_2 laser, a handpiece is moved closer or farther from the tissue in order to change the spot size.

The smaller the spot, the more intense is the effect. Microscope adapters usually have a rotating ring to change this spot. When using fiber delivery with other types of lasers, the closer the tip of the fiber to tissue, the smaller is the spot. Contact probes are frequently used with fibers, in which case the spot is determined physically by the size of the contact probe that is held directly onto the tissue.

Power Density, Spot Size, Power, and Fluence

Power density is expressed in power per unit area. The surface area of the spot (the spot size) and the total power in watts determine the power density as follows.

$$\frac{\text{watts} \times 100}{\pi \times r^2} = \text{watts/cm}^2$$

Note that a change in power (watts) has a linear effect on power density, whereas a change in spot size (r^2) has a logarithmic effect.

Spot Size Versus Impact Size

The spot size is a mathematic measurement of the cross section of a laser beam that contains 86% of its total power [for a transverse electromagnetic mode (TEM00) beam]. It does not necessarily equal the impact size, which may be manipulated to be smaller or larger than the spot size. The optical spot size is theoretical, whereas the actual impact spot of the beam refers to the physical dimensions of the crater or incision. Though it is a useful measurement, one should not heavily rely on the reported spot sizes of various lasers. Each new laser should be tested for its own characteristics on inanimate materials (tongue blades) before clinical use.

The impact size, at any given spot size, will decrease with short pulses or quick strokes of an incision because the beam is not in any one spot long enough for the power of the full spot size cross section to create thermal damage. Conversely, if the pulse is lengthened or the stroke of the incision slowed, the impact size will become broader.

Spot size is determined by the focal length of the lens, the wavelength of the laser, and the transverse electromagnetic mode (TEM) of the beam. The smaller the focal length of the lens, the smaller is the resulting spot and the higher is the power density. A 300 mm lens, such as that used during colposcopy with a CO_2 laser, produces a 0.6 mm spot on most lasers. The same laser used with a handpiece of 125 mm produces a spot of about 0.2 mm, a dramatic difference in power density at the same powers.

The shorter (blue) wavelengths focus to smaller spots than longer (red) wavelengths. This phenomenon is referred to as diffraction limited spot sizes. Argon and KTP lasers can be focused to smaller spots than can the Nd:YAG laser, which in turn can be focused smaller than CO_2 lasers. The choice of laser for a procedure is made according to its specific effects on tissue rather than its diffraction limited spot size. All four of these lasers can be readily focused to fractions of a millimeter spot.

Where Does Power Fit in?

Because power density actually determines the rate of tissue removal, power and spot size can be "traded off" to create equivalent power densities. Power means the rate of energy delivery and becomes important for two reasons.

Power becomes grossly important when working in bloody fields with a CO_2 laser. When tissue bleeds excessively, raw power is required to overcome the "heat sink" effects of the blood. Power in the range of 50–60 watts seems to enable surgeons to perform any procedure. The higher the power above this level, the better and more convienently the laser works. Current models can produce up to 100 watts of output. Lower powers still accomplish most procedures but with less precision, and they will not work in very bloody fields.

In laser medicine, the largest myth about power is that neurosurgeons require high powers for CO_2 laser work; 50–60 watts will work adequately, and most work is performed below 20 watts. Again, high power can be used to advantage but is not necessary to perform most procedures.

The second reason power becomes very important is that it adjusts the size of the laser "paintbrush" with which the surgeon "paints" tissue. Power density determines the rate at which tissue is removed. You can work with a small "brush" by using low powers and small spots, or you can use a larger brush, keeping power density the same, by using high power and larger spots. This method allows the surgeon to cover broader areas in a shorter period of time without actually making the laser any "hotter" by increasing the power density.

The focused spot size of a CO_2 laser, used with a 300 mm lens on a colposcope, is 0.6 mm. Using this size spot at 10 watts of power is exactly the same as using 100 watts of power with a 2 mm spot (actually 1.9 mm). Power densities are the same (about 3500 watts/cm^2); the only difference is that you are now working with the larger 2.0 mm "paintbrush." This concept can be effectively utilized for ablative cones or vulvar stripping.

The second biggest myth about power is that high power is uncontrollable and "dangerous." Power may be controlled in one of two ways: increasing spot size to achieve equivalent power densities or pulsing the laser in short bursts to limit the effect and provide reaction time for the surgeon.

Power is an important concept with other lasers as well, but the CO_2 laser shows these effects more dramatically.

Fluence

The next concept, beyond power density, is that of total energy delivered. Total energy, or joules, equals watts × seconds delivered. For example, 100 joules is equal to either 1 watt for 100 seconds, or 100 watts for 1 second (Fig. 14-6). Whereas power is the concept of the rate of energy delivery, fluence is the concept of intensity of total energy delivery. Fluence combines the concepts of power density with that of total energy delivery and is described in joules per square centimeter. The higher the fluence, the more intense is the spot and the greater is the energy delivered. The significant concept to retain is that one should deliver energy in short bursts at higher peak powers for equivalent energy delivery. This method provides the greatest precision, particularly for CO_2 lasers.

Many lasers provide a direct readout of energy delivered in joules. None of the medical CO_2 lasers incorporate this feature, but most of the continuous wave (CW) Nd:YAG lasers do. No surgical procedure is predicated on a maximum energy delivery in joules: It is the effect you are looking for, not the calculation of energy delivery. Ophthalmic Nd:YAG lasers, those that make "sparks" for intraocular cutting, all have readouts in millijoules which is the primary determinant in treatment.

Confusion over the types of lasers used for various procedures results because of the overlap in tissue effects caused by varying these control parameters. By attaining sufficiently small spots (contact probes), the usual effects associated with the Nd:YAG la-

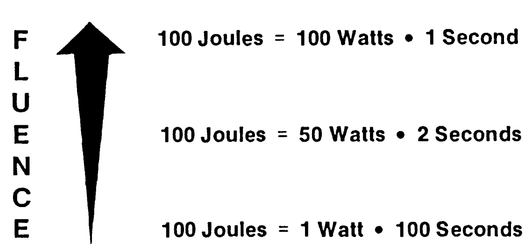

FIGURE 14-6. Fluence is the concept of intensity of total energy delivery described in joules/cm^2. (From Absten GT: Fundamentals of Laser Surgery, copyright © 1985.)

ser may be overwhelmed by the high power densities and heat, thus creating more of a cutting effect than would otherwise occur. The same applies to small spots created by focusing argon lasers. Even though there is some overlap in the effects achieved with these lasers, each has its strengths and predominant uses.

Thermal Effects of Various Lasers on Tissue

Most surgical laser systems work by heating the target tissue and are used as surgical instruments to cut, vaporize, or coagulate tissue. The color of the laser beam determines only how efficiently this thermal transfer occurs in different tissues.

The nature of this thermal transfer can be described in terms of reflection, transmission, scattering, and absorption of light as it hits tissue (Fig. 14-7). In order for light to exert its effect on tissue it must be absorbed. If it is reflected from or transmitted through tissue, no effect will occur. If the light is scattered, it will be absorbed over a larger volume so that the heating effects will be more diffuse.

As soft tissues begin to heat, they first blanch and turn white as protein is denatured, shrivel as they are desiccated, and finally turn to steam and are vaporized as temperatures exceed 100°C (Fig. 14-8).

Regardless of which laser is used for a surgical application, the effects are broadly categorized as follows.

Coagulation
- Protein denaturation and subsequent necrosis
- Hemostasis (cautery)

Vaporization
- Cutting
- Debulking

Acoustic (shock wave effects)
- Membrane disruption (in ophthalmology)
- Stone fragmentation (laser lithotripsy)

When soft tissue is vaporized, the laser causes a "flash boiling" of the cells, throwing off steam and cellular debris (Fig. 14-9). The steam and debris are seen as the laser plume, which looks like smoke. Laser plume should be eliminated by the use of a good smoke evacuation system. The particle fragments left behind flash white hot as they are carbonized.

When considering the effects of various lasers on tissue, one can see that the CO_2 laser is most highly absorbed, the argon and KTP lasers slightly scattered, and the Nd:YAG

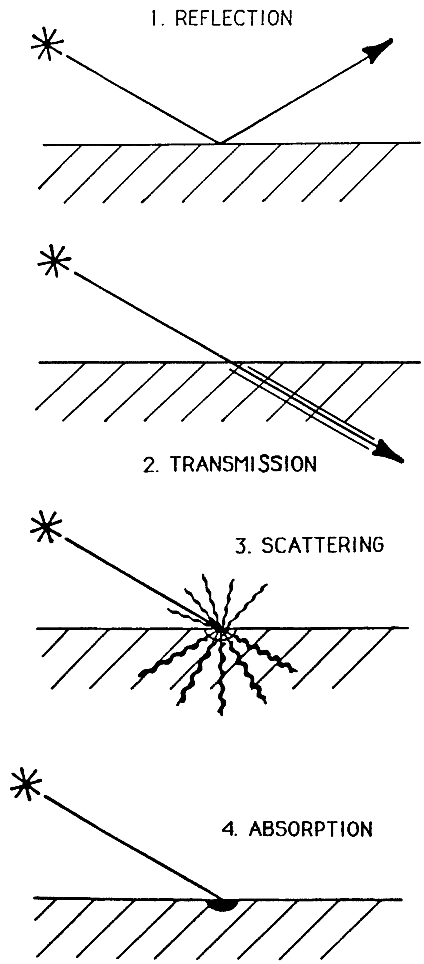

FIGURE 14-7. Interaction of tissue with the laser beam. (From Absten GT: Fundamentals of Laser Surgery, copyright © 1985.)

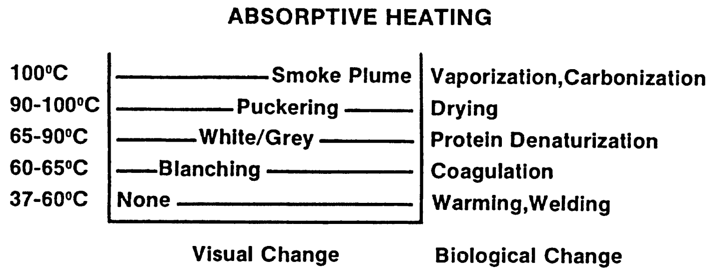

FIGURE 14-8. Laser effects on tissue: absorptive heating. (From Absten GT: Fundamentals of Laser Surgery, copyright © 1985.)

laser highly scattered (Fig. 14-10). This difference indicates that the CO_2 laser is best used to cut and vaporize tissue quickly. The Nd:YAG laser coagulates protein in a larger volume without necessarily vaporizing it, though it will vaporize with more applied energy. The argon and KTP lasers are pigment sensitive and superficial coagulators of lower power than CO_2 and Nd:YAG lasers. They reflect off nonpigmented tissue but scatter and absorb in red and dark tissues. These tissue effects refer only to the diffuse laser light. Overlap in effects and applications can be readily achieved by varying spot sizes, delivery systems, and pulsing techniques.

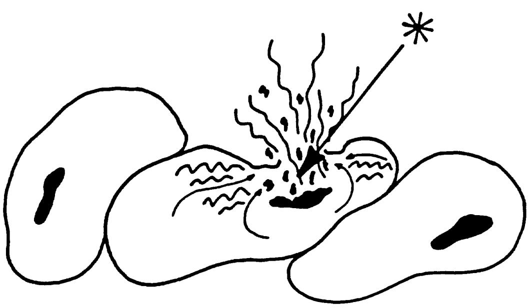

FIGURE 14-9. Vaporization of soft tissue. (From Absten GT: Fundamentals of Laser Surgery, copyright © 1985.)

Laser Types and Delivery Systems

CO_2 Laser

The CO_2 laser is primarily a specialty device used in neurosurgery, otolaryngology, gynecology, podiatry, plastic surgery, and dermatology. It is a precision instrument in that it

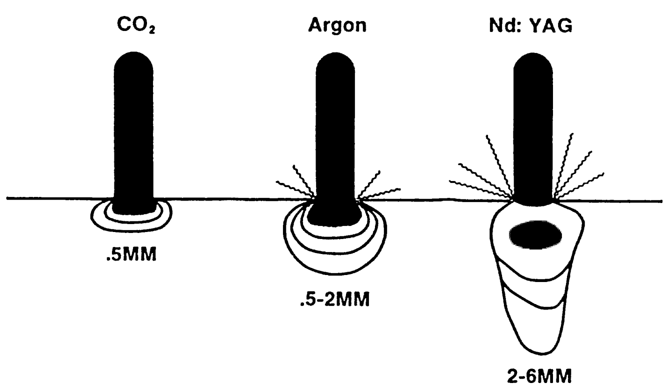

FIGURE 14-10. Tissue absorption depth with the CO_2, argon, and Nd:YAG lasers. (From Absten GT: Fundamentals of Laser Surgery, copyright © 1985.)

can remove tissue in a no-touch technique and may significantly reduce postoperative pain in selected cases. It seals lymphatics as it cuts, which may reduce spread of malignant cells. Though offering less hemostasis than electrocautery, there is usually less damage associated with the CO_2 laser.

In learning the correct use of CO_2 lasers, there are three classic mistakes to avoid. The first is the use of more power than the surgeon can control and that may result in penetrating tissue or cutting too deeply. One avoids this problem by adjusting the spot size to create the correct beam geometry. The second mistake is exactly opposite, which is spending excessive time on tissue because of very low power. When used in delicate areas it creates significant spread of heat damage and destruction of adjacent tissue. It is avoided by using higher power and pulsing with short pulses. The short pulses avoid the excessive damage from the power and allow cooling of tissue between pulses. The third mistake involves re-lasing over char created by the laser. It increases the surface temperatures from just over 100°C for the first pass to over 1500°C when lasing through the char. On skin, as in vulvar work, it would cause significant heat spread and scarring. It is avoided by wiping away char with a moist sponge before lasing the same area. Lasing through char does offer excellent hemostasis because of the heat spread, and in some situations it may be warranted, i.e., when debulking a vascular tumor or cutting a vascular organ.

The depth of an incision using the CO_2 laser is determined by both power density (power and spot size) and the duration of application (speed of the stroke). The "feel" for controlling the depth of the incision is developed by practice and by visualizing the field. It is important to maintain traction and countertraction across the line of the incision to achieve a good, clean cut.

When making an incision, the surgeon should always choose the smallest spot size available (focused). Power then simply controls the speed of the incision. It is recommended to start at low speed and quickly work up to a comfortable speed.

A CO_2 laser incision provides better hemostasis than cold steel but is not quite as clean a cut, though it is cleaner than with electrocautery. The black char that forms at the edges of a laser incision is superficial and can be removed with irrigation. When used correctly, the lateral zone of damage from the cut is about 0.5 mm, compared with 5–10 mm with electrocautery. Surrounding tissue exhibits minimal edema, scarring, or stenosis.

The depth of the incision can be readily seen, but once the beam has penetrated the tissue it instantly burns whatever tissue is behind. Some type of backstop is needed when cutting all the way through membranes, tubes, or other structures. Wet sponges or cottonoids may be used, and quartz or titanium rods work for finer dissections.

Incisions are made with the beam in focus. Debulking or vaporizing tissue is usually performed with the beam in a defocused mode (Fig. 14-11). Small areas can be vaporized with a focused spot. However, larger areas may develop ridges and furrows when using the "sharp" beam, which tends to cause excessive bleeding and leaves a shredded tissue effect. A defocused beam, at sufficient power, provides for a smoother,

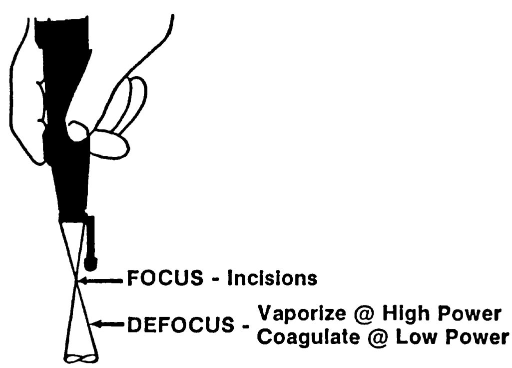

FIGURE 14-11. Incisions are made with the beam in focus. Debulking or vaporizing of tissue is usually performed with the beam in a defocused mode producing a "scoop-like" beam geometry. (From Absten GT: Fundamentals of Laser Surgery, copyright © 1985.)

blunter, more scoop-like ablation than a focused beam. Hemostasis and visibility are also more effective. Ablative conizations are best performed with the defocused beam.

The CO_2 laser is delivered through an articulated arm rather than fibers. This device is a hollow metal tube that contains mirrors within movable joints to bounce the beam out of the end of the arm. Various delivery systems may then be attached to the end of the arm. CO_2 laser fibers are in various stages of development from many companies, but all have significant problems that impede their practical use. A small, hollow waveguide, similar to a fiber in diameter, is available for laparoscopy. A "waveguide" is a slender needle-like tube that looks similar to a fiber but is not flexible and works by sending the beam down the thin, hollow tube. When fibers become available they will not replace articulated arms in the forseeable future. Articulated arms allow delivery of higher powers and retain the "clean shape" of the beam. Fibers destroy these properties and will best be used as attachments to articulated arms when endoscopic delivery is desirable.

Handpieces that attach to the arm function the same as a "magnifying glass" with the sun. They are moved farther away from tissue to defocus the beam and reduce power density. The focal length of the lens indicates the distance where the spot will be smallest and the beam the sharpest. A 125 mm focal length is typical for standard handpieces.

Micromanipulators are laser adapters that attach to the underside of operating microscopes for beam delivery. The laser travels through a separate laser lens for focusing and does not pass through the optics of the microscope. Many micromanipulators integrate continuously variable defocus (CVD) devices, which allow the beam to be defocused by twisting on the device (Fig. 14-12). Colposcopy and laparotomy procedures usually require a 300 mm focal length for the microscope and laser. Remember that the micromanipulator takes up some of the working space of the lens, so that a 200 mm lens on the microscope would not provide enough room to work between tissue and micromanipulator. When the focal length of the laser increases, as it does with the microscope, the beam will also be in focus for a longer distance from the focal point. This increased depth of field requires that one be more careful about penetrating underlying structures, as it is focused for a longer period of time.

The CO_2 laser is used through special la-

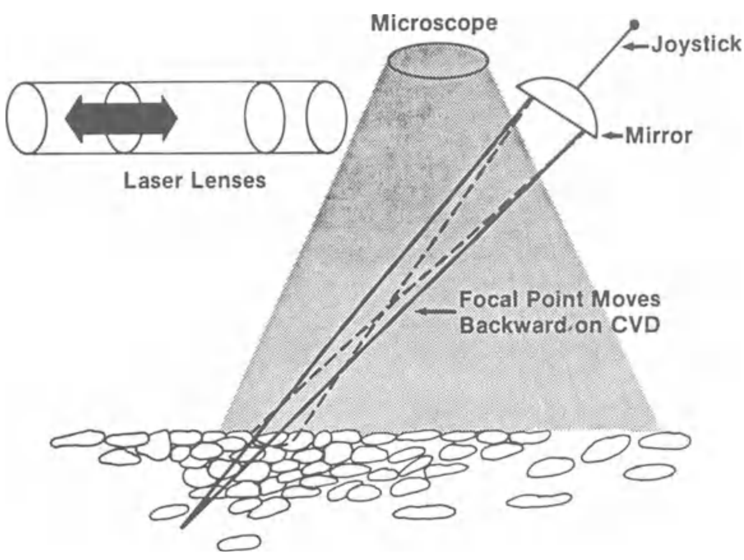

FIGURE 14-12. Continuously variable defocus device allows the beam to be defocused by twisting on the device. (From Absten GT: Fundamentals of Laser Surgery, copyright © 1985.)

ser laparoscopes. Because the focal length is about 300 mm, the depth of field is also large and one must be careful not to penetrate structures deep within the pelvis if a backstop is not used. A variety of laparoscopic backstops are available; alternatively, fluid will stop the beam.

Miscellaneous other attachments are also available for the CO_2 lasers such as rigid bronchoscopes and scanners.

Because the CO_2 laser beam is invisible, a red helium neon (HeNe) laser is used as the guide light so one can aim the laser. The laser must be test fired before each use to ensure that the laser burns within the red dot.

Nd:YAG Laser

The Nd:YAG (neodymium:yttrium aluminum garnet) laser is the primary endoscopic laser because it passes so easily through conventional fibers 0.2–0.8 mm diameter. The entire fiber catheter may measure 1.5–2.5 mm in diameter when an outer sheath for cooling gas or fluid is required, as for gastroenterology, pulmonary, or laparoscopic applications. In hysteroscopy and cystoscopy a bare fiber may be used, as the fluid in the cavity will dissipate the heat from the tip of the fiber.

When used with standard fibers, the Nd:YAG scatters through tissue and produces a diffuse coagulation over a depth of 4–6 mm. The beam diverges from the end of the fiber so that the smallest spot is right at the end of the fiber, increasing with distance from the fiber. At higher power densities, it will vaporize tissue but still produce the diffuse coagulation beyond the crater, which makes it an excellent coagulating and fulgurating instrument. It is used to debulk obstructive gastrointestinal and pulmonary tumors, coagulate bladder tumors, and stop bleeding endoscopically. Like the argon and KTP lasers, the Nd:YAG may be used endoscopically in fluid-filled cavities such as the uterus. Its major use in gynecology thus far has been for endometrial ablation to treat menorrhagia. In laparoscopy, it may be used with probes for treating endometriosis (see Chap. 17).

The Nd:YAG laser has been used primarily in bronchoscopy, gastroenterology, urology, and hysteroscopy. To a lesser extent, it is used in neurosurgery, dermatology, plastic surgery, and laparoscopy.

The use of contact sapphire probes has significantly expanded the versatility of the Nd:YAG laser and may eventually contribute to its widespread use in general surgery. Unlike regular fibers, which should not be touched to tissue, these probes are used in contact with tissue. This method returns a tactile sense to the surgeon and prevents tissue damage from occurring except where it is in direct contact with the probe. The probes collect and concentrate the laser energy to small points. Touching tissue is required to create an effect. The application of very low powers results in very high power densities and intense heating of the probe. Probes allow for cutting and vaporization of tissue without the diffuse coagulation damage that would normally occur. The different shapes of the various probes produce different effects. With contact probes, the Nd:YAG laser can be used to coagulate, cut, or vaporize tissue and offers excellent hemostasis in most tissue. Most of the effect comes directly from heating the sapphire crystal, causing direct thermal vaporization of tissue. The relative merits of how much of the effect is due to direct heat and how much is due to indirect heat through power density is irrelevant, as it is the observable tissue effect that is important.

Contact probes are available as hand-held scalpels or as small probes that fit on the end of fibers for endoscopic delivery. They must not be fired when not in contact with tissue as it would result in the melting of these relatively expensive probes.

Contact probes do expand the use of the Nd:YAG laser. However, they will not eliminate the use of conventional fibers for some applications because they limit coagulation necrosis. In endometrial ablation, for example, the deeper coagulation from a bare fiber and higher powers is desirable. They do not replace the use of the CO_2 laser, but the expanded versatility does cause some overlap in applications. Though offering more control and tactile feedback for cutting, contact probes require more time than the CO_2 laser to achieve the desired effect. The experience and training of the surgeon will determine, in large part, what laser is to be used. Contact probes used with the Nd:YAG laser are much easier to learn than the no-touch technique of the CO_2 laser but do not offer the speed and versatility of the latter. On the other hand, contact probes used with the Nd:YAG laser offers flexible endoscopic delivery, which the CO_2 laser is unable to provide. Contact probes will also soon be available for argon lasers.

The Nd:YAG laser used in ophthalmology is totally different than that used endoscopically for general surgery. The ophthalmic units are fast pulsed at tens of millions of watts of power (Q-switch) creating a small spark and shock that snaps apart membranes in the eye.

Green (Argon and KTP) Lasers

Argon lasers use argon gas to produce a blue-green light of 488 and 515 nm. Power outputs range from about 5 to 16 watts from the fibers.

KTP (potassium titanyl phosphate) lasers are actually Nd:YAG lasers that are shot through a frequency-doubling KTP crystal to change the wavelength to 532 nm (green). It is a frequency-doubled Nd:YAG laser, except that all the residual 1064 nm light has been filtered out. They have no tissue effects in common with the Nd:YAG laser. Power of about 10–16 watts can be delivered from the fiber. It is a high frequency pulsed system rather than a continuous wave system like the argon laser, but it pulses so fast it appears continuous.

The KTP laser is a slightly greener beam than the argon laser. There are some subtle differences between these colors in terms of tissue effects, but for practical purposes their tissue effects are the same. The fibers are dragged across tissue to cut, pulled away a little for vaporization, and pulled further away for superficial coagulation. There are advantages and disadvantages to each type of laser in terms of price, delivery systems, and maintenance.

The argon and KTP lasers produce much less power than the CO_2 or Nd:YAG laser but can be focused to small spots. Their usual effect is a superficial coagulation 0.5–2.0 mm in depth. These lasers can be focused to cut but take much more time to vaporize. These lasers are color selective when coagulating, absorbing best into red or black tissue.

The primary use for argon lasers has been in ophthalmology as retinal photocoagulators. They have also seen use in dermatology because of their color selectivity for cosmetic lesions. Otolaryngologists use them for precision middle ear work and less frequently for microlaryngoscopy. Because they are also fiberoptic systems, they have gained use for laparoscopic treatment of endometriosis. The advantages, which are similar to those of the Nd:YAG laser with contact probes, include fiber delivery, little if any production of smoke, and ease of maintaining pneumoperitoneum.

The argon and KTP bare fiber lasers, *as with* all fiberoptic laser systems, can be "dragged" across adhesions for cutting. Surgical control is much easier and safer than with CO_2 lasers. The fiber divergence prevents damage to structures behind the adhesions. Moving the fiber tip 1 cm toward or away from the target creates dramatically different effects from the changing power density, such as coagulation, vaporization, or cutting. This makes fiberoptic systems easier to control allowing for rapid changing effects, safer for distal structures, and easier to maintain pneumoperitoneum because of the reduction in smoke. Though CO_2 lasers are now the standard, fiberoptic laser systems (argon, KTP, and contact Nd:YAG) are definitely the trend in laparoscopic treatment of endometriosis and adhesions.

Micromanipulators are available for argon and KTP lasers. Very small spot sizes are possible, resulting in a high degree of precision. They take longer to achieve the effect because of relatively low power (10–18 watts).

Summary

Significant overlap in applications of the various lasers can result because of the variables of laser delivery, power densities, pulsing, powers, etc.

The CO_2 laser is a specialty instrument, particularly for microscopic applications in gynecology. Its hemostasis and vaporizing abilities make it a valuable tool for tumor resection and hemostasis. In gynecology it is best suited for colposcopy of the cervix and vulva and for laparotomy through a micromanipulator.

The Nd:YAG laser is the primary endoscopic instrument for pulmonary, gastroenterology, and urology applications. The use of contact probes, though not a panacea, will increase its applications. Its primary use in gynecology is for endometrial ablation with bare fibers for deep coagulation. Its use in laparoscopy with contact probes is quickly growing.

Green light lasers (argon and KTP) are color-selective photocoagulators. In some configurations they may be used to cut tissue and are fiberoptic. Their best use in gynecology appears to be for laparoscopic treatment of endometriosis.

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15
Laser Equipment

JOHN L. MARLOW

Progress in laser laparoscopy has been proportional to the innovations made in instrument design. The first laser equipment used in laparoscopy was adapted from instruments used in otolaryngology. Although these instruments were useful in treating vocal cord diseases through the laryngoscope, they were cumbersome, bulky, and difficult to keep aligned when first adapted to the laparoscope. Within the closed peritoneal chamber, smoke was produced from tissue vaporization and clouded the view. It required aspiration to maintain visual control, which collapsed the pneumoperitoneum. The first generation of insufflators refilled the compartment slowly, prolonging the surgery. Despite these early problems, surgeons have demonstrated the advantages of laser laparoscopic surgery with increasing use of the improved instrumentation. This chapter will review the current instrumentation used in laser laparoscopy.

History

Interest in surgical applications of laser instruments came early in the history of lasers. Laboratory bench-top lasers were first tested in living tissue by delivering the beam from horizontal laser chambers to the tissue, which was drawn into the beam and the effects recorded. Calibration of power density, beam configurations, and useful wavelengths for surgery were those obtained from the laboratory instruments used by basic scientists. The first generation of equipment designed for surgeons was bulky and large. One of the first surgical CO_2 lasers was as big as a telephone booth.[1]

The first endoscopic laser instruments were developed in the late 1960s. Jako performed in vivo laser surgery on the canine larynx and demonstrated its usefulness.[2] He used a 15 mm laryngoscope with a lens attached just beyond the distal end of the endoscope. This basic instrumentation, which delivered the laser beam through hollow channels, served as the model for the first laparoscope.

Laser Instruments

Four lasers are used today with the laparoscope.

Carbon Dioxide Laser

Following its development in 1964 at Bell Laboratories by Patel, the CO_2 laser was the first used in gynecologic surgery.[3] Its successful introduction into gynecologic surgery came in the mid-1970s for the treatment of lower genital tract disease.[4] The energy source for the CO_2 laser is high voltage electrical or radiofrequency power. The laser cavity, in which the laser beam is created, is an optical resonator that contains a gas medium. Two gas systems are available:

flow-through and sealed systems. Flow-through systems contain mixtures of carbon dioxide, helium, and nitrogen (Fig. 15-1). The gas mixture flows longitudinally through the hollow cavity. Increasing flow rates dissipate heat and result in more power. The precise ratio of gases may vary slightly from instrument to instrument to obtain the optimum benefits. After the laser beam is generated, the gas mixture is vented, which requires replacement of the vapor. Sealed lasers eliminate the need to replace the gas tanks. However, these sealed components are more expensive and usually cannot deliver as high a power output per length of sealed laser. The sealed chamber may degenerate over a period of time and will require replacement. One advantage of the CO_2 laser instruments is that they do not require special electrical or plumbing fixtures. The characteristics of CO_2 lasers used in laparoscopy are listed in Table 15-1.

TABLE 15-1. CO_2 laser

Wavelength:	10,600 nm
Tissue penetration:	Superficial
Peak power:	>100 watts
Scatter:	None
Color dependent:	No
Fiber transmission:	In development
Hemostasis:	Poor for vessels larger than beam
Fluid transmission:	No
Eye protection:	Clear glass or plastic eyeware
Strengths:	Precision of vaporization Minimal adjacent tissue injury Visual control of tissue effects

FIGURE 15-1. CO_2 flow-through laser instrument. (Courtesy of Sharplan Lasers, Inc., Allendale, New Jersey.)

Argon and KTP Lasers

Argon was the first laser used in medicine (Fig. 15-2). In 1964, Bridges reported the development of ionized argon production.[5] It was first used to treat intraocular hemorrhage and detached retinas. The visible blue-green beam of argon and the emerald green beam of KTP (potassium titanyl phosphate) is highly absorbed by blood and pigmented tissue. These laser beams pass through clear body fluids, such as that within the eye, producing no thermal effect. These laser generators also use electrical energy as their power source. Continuous wave argon lasers require high electrical current densities—in excess of 100 amperes per centimeter passing through the gas.[6] A major advantage of these lasers in laparoscopy is the ability to deliver the beam to the peritoneal chamber through small flexible fibers. The laser console can be positioned a great distance from the operating table with the laser energy delivered through a long quartz fiberoptical bundle to the operating field. These laser fibers range in size from 300 to 600 μm in diameter and can be introduced through small channels in the operating laparoscope or ancillary trocars. The tips of the laser fiber can be steered with special bridges. Some type of protective coating on

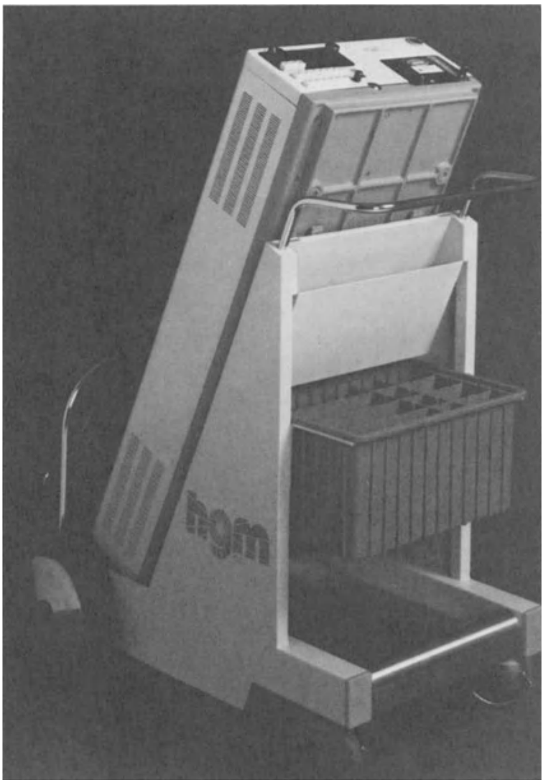

FIGURE 15-2. Argon laser instrument. (Courtesy of HGM Medical Laser Systems, Inc., Salt Lake City, Utah.)

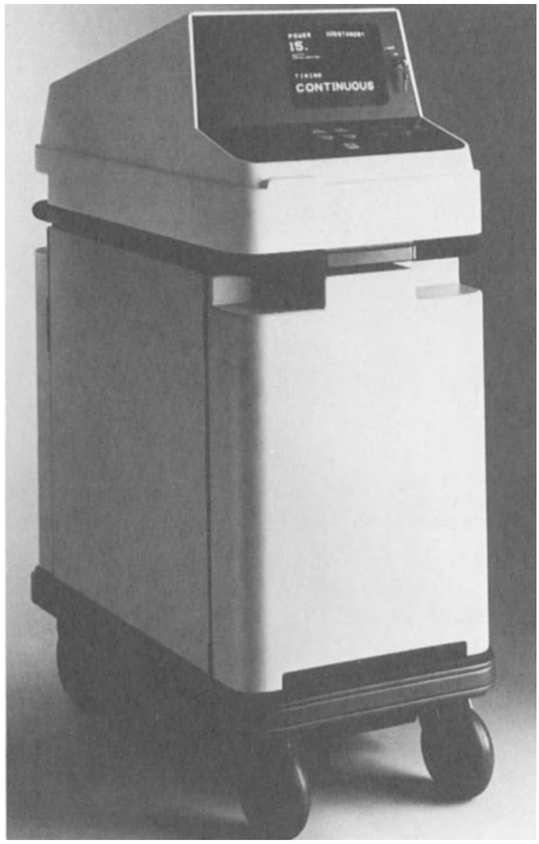

FIGURE 15-3. KTP 532 laser system. (Courtesy of Laserscope, San Jose, California.)

the fibers is usually provided. With use, the fiber requires replacement, and disposable fibers are now available. These lasers require special cooling because of the large amount of heat created in generating the laser beam. The generators require a special electrical hookup, usually 230 volt, 30 ampere sources, and plumbing attachments. KTP lasers deliver a single wavelength beam at 532 nm, which is generated by modifying a YAG laser beam (Fig. 15-3). The KTP crystal doubles the frequency and changes the wavelength from 1064 to 532. The properties of these two lasers are listed in Table 15-2.

Neodymium-YAG Laser

Neodymium in glass laser was developed in 1961 by Snitzer.[7] Neodymium-yttrium aluminum garnet (YAG) lasers are useful because of their superior hemostatic ability and their capacity to effectively coagulate large volumes of tissue. The laser beam is generated from a gold-plated optical cavity.

TABLE 15-2. Argon and KTP lasers

Wavelength	
Argon	488–514 nm
KTP	532 nm
Tissue penetration:	1–2 mm
Peak power:	20 watts
Scatter:	Yes
Color dependent:	Yes
Fiber transmission:	Yes
Hemostasis:	Good
Eye protection:	Special lenses
Strengths:	Selective absorption Fiberoptical transmission

TABLE 15-3. Neodymium-YAG Laser

Wavelength:	1064 nm
Peak power:	>100 watts
Tissue penetration:	To 6 mm
Scatter:	Yes, forward and backward
Color dependent:	No
Fiber transmission:	Yes
Hemostasis:	Good
Fluid transmission:	Yes
Eye protection:	Special lenses
Strengths:	Good coagulation of large volumes of tissue
	Good for bleeding
	Sapphire tips for contact
	Laser use

The optical energy is coupled from a krypton arc lamp to the Nd:YAG. The depth of treatment with the YAG laser is deeper than with the CO_2, KTP, or argon laser. Like the colored lasers, the YAG laser can be delivered through fiberoptical bundles with the advantages noted above. YAG lasers were first used in gastroenterology because of their hemostatic capacity. In gynecologic surgery its first uses were through the hysteroscope for endometrial ablation. Its application through the laparoscope has been of recent interest. Specialized (e.g., sapphire) tips, applied to the tip of the laser fiber can modify the laser effects and provide a tool for contact laser surgery. The YAG laser has great potential in treating disease with high vascularity and where there is a large bulk of tissue to be treated. The depth of treatment cannot be visually monitored and may extend 6 mm beyond the tip. Care in treatment near vital structures such as ureters, major blood vessels, and the bowel wall must be exercised. The YAG laser uses electrical voltage as the energy source and a solid crystal as generating matter. Properties of the Nd:YAG laser are listed in Table 15-3.

Control Panels

The laser instrument console contains a control panel that allows the surgeon several options to modify the laser beam. (Fig. 15-4). The number of options available are proportional to the sophistication and cost of the instrument. Access to the panel is controlled by means of a key, which restricts the laser's use to those with appropriate training and authority. The control panel allows adjustments of power, tissue exposure, pulse intervals, repetition rates, pulse width, and other modifications in the most advanced instruments. Calculation of the total joules of energy delivered, number of pulses applied, power densities, messages of instrument faults, and corrections can also be provided.

FIGURE 15-4. Laser instrument console. (Courtesy of Sharplan Lasers, Inc., Allendale, New Jersey.)

TABLE 15-4. Laser console

Access key
Laser ready and standby switch
Power control
Exposure control
Single pulse
Repeat pulse
Interval time
Continuous
Beam configuration
Superpulse
Chopped pulse
Status reports
Fault identification
Messages of problems and solutions
Dosimetry
Power density
Joules
Pulses

Hardcopy printout of such information is possible. Table 15-4 outlines some console options. (The reader is also referred to Chapter 16 for more information regarding the control panel and safety features.)

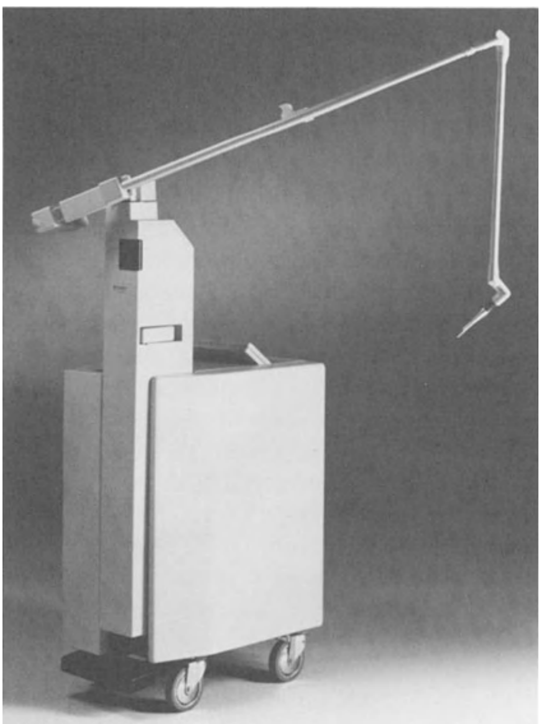

FIGURE 15-5. Articulated arm with sealed gas system XL55 CO_2 laser. (Courtesy of Coherent, Inc., Palo Alto, California.)

Delivery Systems

Articulated Arms

The CO_2 laser beam produced within the generator is directed from the optical resonator through articulated arms containing six or seven metallic mirrors. These mirrors are precisely aligned to preserve the configuration and power of the beam. In this way, the CO_2 laser beam is delivered to the operative field some distance from its source.[8] The height and length of the articulated arm delivery system dictates how far away the console may be positioned (Fig. 15-5). Arm improvements have included graphite composition for lighter weight and better and more dependable mirror alignment, which have decreased the need for maintenance adjustments of the arm mirrors.

Lenses

The laser beam exiting from the arm is directed into lenses in order to focus the energy on tissue. These lenses, referred to as coupling lenses, serve to direct the beam into the laparoscope or ancillary instrument. Two types of lens are available: fixed focal and variable focus lenses. The fixed lens is a simple coupling lens that can be easily assembled between the arm and the laparoscope. The variable focus lenses allow the surgeon to focus and defocus the beam and change the spot size. In laparoscopic use, these lenses usually have focal lengths of 100–315 mm, with their focal point approximately 2.0 cm from the end of the laparoscope. Available lenses can produce spot sizes from 0.5 to over 2.0 mm through the laparoscope.

The laser beam can be delivered through an operative laparoscope channel with a single puncture or through secondary trocars with multiple punctures in the lower abdomen. Formerly, CO_2 lasers required large channels of up to 7 mm in diameter because of the alignment problems. The direction of the laser beam was controlled by an aligning laser coupler. The inconvenience of beam alignment has stimulated the development of new instrumentation, such as rigid wave guides.

Rigid Wave Guides

Rigid wave guides are hollow metal tubes with dielectric or metallic linings of a different index refraction from air (Fig. 15-6). Because the core of the tube is free of energy absorption, minimal loss of power is accomplished. These dielectric or nonconducting wave guides may use ceramics and can be delivered through a very small diameter. The metallic wave guides have a high index of refraction and can transmit relatively high power densities. If the tube is bent, however, the power loss may be significant. A purge of continuous carbon dioxide of up to 1000 cm^3/min maintains a clear channel within the guide. The gas insufflation is useful in CO_2 laser laparoscopy as an additional source to replace gas evacuated with suctioning of the smoke. The wave guide has a small diameter (3 mm) and is simple to attach to the articulated arm.[9] Visualizing the helium-neon aiming beam is not critical with this delivery, as the guide is held in close proximity to the tissue when in use. The impact site of the beam lies immediately beyond the tip of the wave guide. Table 15-5 outlines some wave guide properties.

TABLE 15-5. Rigid wave guide

Diameter:	3.0 mm
Length:	30–50 cm
Power transmission:	1–80 watts
Spot size:	0.8–1.2 mm
Divergence:	3°
Power loss:	10%

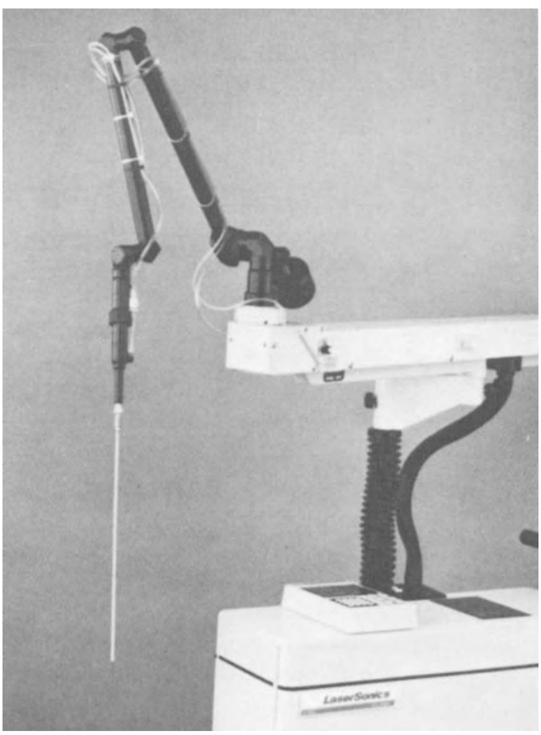

FIGURE 15-6. Rigid wave guide setup with CO_2 laser. (Courtesy of Heraeus Lasersonics, Inc., Santa Clara, California.)

Fiber Delivery

The ability to deliver the laser by fiberoptics is a major advantage of argon, KTP, and Nd:YAG lasers. Compared with articulated arms, fibers are easier to use, more flexible, lighter in weight, and of smaller caliber, and they can be delivered from a greater distance. The laser console can be positioned outside the immediate operative area and supply the laser beam through a network not unlike that used in electrical circuits. The laser fibers can be adapted to many of the conventional laparoscopy instruments available today without the need to purchase specialized equipment. Direct tissue contact is possible with or without modified tips such as those made of sapphire. Although of more concern in hysteroscopy than laparoscopy, laser energy transmission through fluid is possible with fiberoptics. Reports have suggested that useful CO_2 laser fibers may soon be available.[10,11] The previous problems in developing a CO_2 laser fiber, such as toxicity, shielding, and energy losses, have delayed this potentially useful delivery system. In addition to delivering the laser beam, fiberoptics may in the future also be used to monitor laser surgery. Sensor data can be returned to console computers for an analysis of tissue effects through the same fiberoptical bundles used to deliver the beam. This type of back-and-forth transmission of light is commonplace in the communication industry today.

Ancillary Probes

Ancillary probes are useful in laser laparoscopy for aspiration of smoke and peritoneal fluids. They can be positioned near the impact site of the laser beam to remove the plume and to maintain a clear viewing space. They can be used to irrigate the operative field with fluids such as Ringer's lactate solution (Fig. 15-7). This pooled fluid in turn can be used as a backstop for the CO_2 laser. After laser treatment, aspiration of the fluid along with blood and carbonized tissue particles removes these contaminants from the field. Secondary laparoscopy probes provide entry ports for the laser beam to be delivered through the lower abdomen. Lateral lower abdominal entry provides a useful delivery angle in treating adnexal disease. Ancillary probe tips with backstop, mirror, or aspiration tips are provided (Fig. 15-8). Secondary probes are usually 3–5 mm in diameter and up to 28 cm in length. Inner probe channels measuring 0.5–1.3 mm accept laser fibers. Adjustable bridges at the tip of the probe direct the fiber to the lateral pelvis or areas of difficult access. Grasping instruments are useful in laser laparoscopy for manipulation and traction as well as producing a backstop. A matte or irregular finish on these instruments helps to disperse the laser beam when it is used as a backstop.

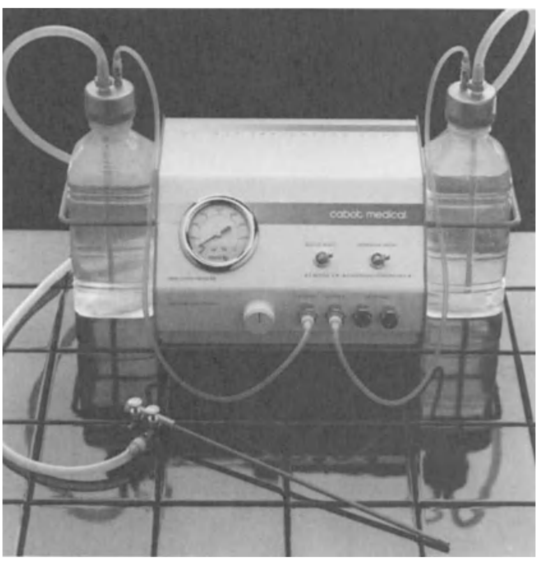

FIGURE 15-7. The Cabot Medical Irrigation Pump and Probe provides an ideal irrigation and water dissection system for operative laparoscopy. (Courtesy of Cabot Medical, Langhorne, Pennsylvania.)

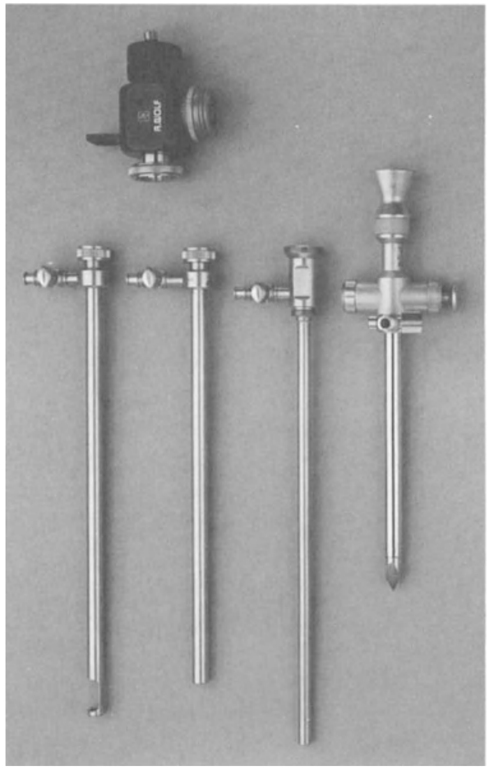

FIGURE 15-8. CO_2 laser ancillary probes, laser tubes with and without backstop, trocar and sleeve, and aiming laser coupler. (Courtesy of Richard Wolf Medical Instrument Corp., Rosemont, Illinois.)

Televised Laser Laparoscopy

The combined use of television and laser laparoscopy has been one of the most significant improvements for the surgeon. Because the laser beam is controlled through the laparoscope using visual images and television provides a large, easily seen image, it follows that television can be a useful adjunct to this type of surgery. Television has become an integral part of laser laparoscopy in an increasing number of surgical centers. Small computer chip cameras have been designed that measure 0.5 inch in diameter, weigh 4–6 ounces, and can be attached to the laparoscope (Fig. 15-9). Split-beam lenses allow the surgeon and operating team to view the surgical field simultaneously. Image resolutions up to 600 lines provide clear pictures. Cameras with low light sensitivities, as low as 10 lux, allow recordings through small caliber laparoscopes with conventional light sources.

With these improved cameras and monitors, excellent large images can be seen by the entire operating team. Surgeon fatigue is decreased because of the decreased need to bend over during the procedure, which is important in some prolonged laser laparoscopy cases. Improved coordination of the surgical team is possible because everyone can see the surgical field. Simultaneously, permanent color recordings, still and in motion, are easily obtained. Some advantages of the use of television in laser laparoscopy are listed in Table 15-6.

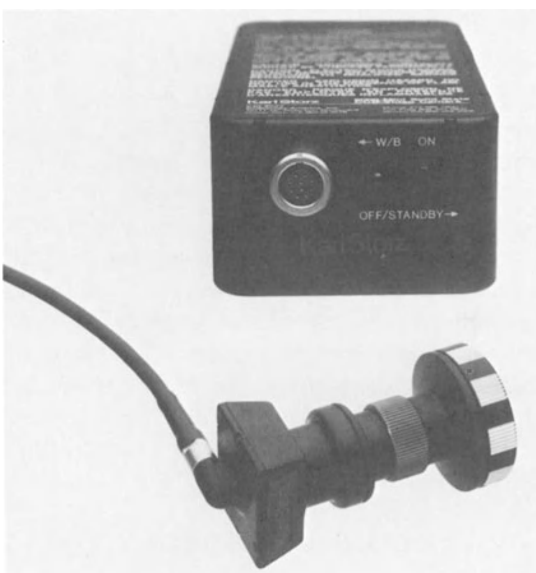

FIGURE 15-9. Computer chip television camera with laparoscopic eyepiece adaptor. (Courtesy of Karl Storz Endoscopy–America, Inc.)

TABLE 15-6. Television advantages in laser laparoscopy

Reduction of surgeon fatigue from bending
Coordination of surgical team
Education of
Operating team
Resident physician
Patient and family
Provide patient records and referral reports
Consultation
Preoperative
Intraoperative
Postoperative

Laser Gas Insufflators and Smoke Evacuators

Laser vaporization produces smoke, which accumulates within the peritoneal chamber in laparoscopy and can obscure the surgeon's view. Evacuation of the smoke depletes the pneumoperitoneum, which in turn requires frequent refilling of the compartment. Newer laser laparoscopy insufflation instruments provide adjustable rapid flow rates of 1–5 L/min. Refilling is triggered by the fall in the intraabdominal pressure concomitant with smoke evacuation. Gas is refilled from the main gas reservoir, eliminating the need for repeated refilling as is the case with the older and smaller capacity insufflators.

Smoke evacuators are necessary when vaporization of tissue results in a plume that consists of water, elemental carbon, and tissue fragments. The plume may also create a distinct malodor. All of these elements require filtering.

The American College of Surgeons' Standard of Clean Air states that particles in the air 5 μm or larger support bacterial colonization. Most laser plume studies indicate particles from the laser are less than 1.1 μm. Current evacuators on the market are capable of removing particles as small as 0.1 μm.

Foot pedal and trumpet valves on certain instruments allow the surgeon precise control of smoke evacuation. Smoke evacuation and eye protection equipment are discussed in Chapter 16.

Instrument Regulation and Labeling

Manufacturers of lasers are under the regulation of the Food and Drug Administration (FDA). A code of Federal Regulations Performance Standards for Light Emitting Products has been established. The Bureau of Radiological Health is also involved with these regulations. Most lasers used in surgery are class IV.

Under the FDA's Bureau of Radiologic Health, the manufacturers of laser equipment are required to apply specific labeling to laser instruments. This requirement was mandated by the radiation control for the Health and Safety Act of 1968. The format, content, color, and class of the laser must be specified in the label. In addition, the aperture of the exit path of the laser beam must also be labeled.

Clinical Uses of Laser Laparoscopy

Laser laparoscopy has been useful in several clinical areas, including treatment of endometriosis, adhesions, infertility surgery, and pelvic pain. These uses are listed in Table 15-7.

TABLE 15-7. Laser laparoscopy: clinical uses

1. Adhesiolysis
2. Endometriosis ablation and excision
3. Distal tubal obstruction incision and eversion
4. Fimbrioplasty incision
5. Pelvic abdominal pain: uterosacral nerve ablation (LUNA)
6. Ovarian sclerocystic disease, benign fibroma: incision and focal vaporization
7. Fimbrial cyst ablation and fenestration
8. Small subserosal fibroid vaporization
9. Ectopic pregnancy incision and excision

Instrument Care and Repair

Laser instruments are complex, sophisticated tools and require specialized maintenance and repair (Fig. 5-10), which is an important consideration in the acquisition and use of laser laparoscopy instruments. Identifying maintenance personnel and response time for repair of instrument failure is important. Maintenance service contracts are useful to define this resource. Fortunately, instrument down time with current systems is minimal. Scheduled periodic maintenance and instrument evaluation are important to keep the equipment operating at peak performance. Large volume laser centers also have backup instruments available should the laser malfunction, thereby reducing the necessity to reschedule surgery. Instrument damage can be reduced through in-service programs from the laser manufacturer. Instrument orientation for operating room personnel is essential to reduce this damage. Minor troubleshooting in the hospital can be

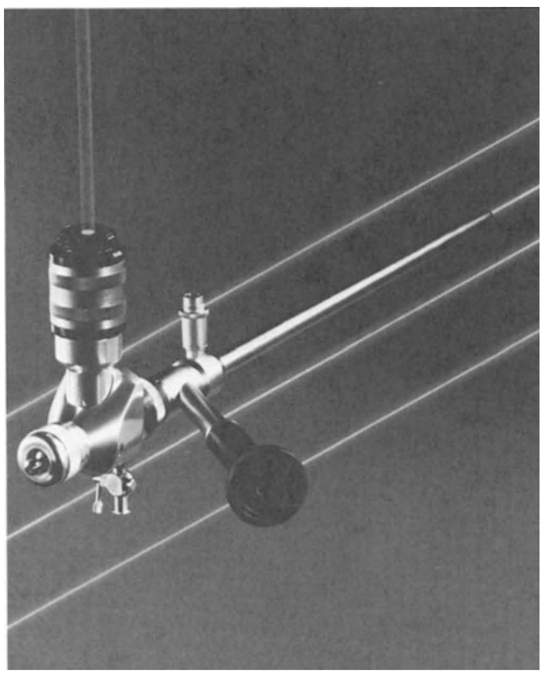

FIGURE 15-10. Single-puncture CO_2 laser laparoscope (Courtesy of Olympus Corp., Lake Success, New York.)

provided by the laser nurse coordinator or laser safety officer. Preoperative, intraoperative, and postoperative instrument checks should be performed implementing established laser policies. Periodic checks on the instrument such as oil and water levels, gas pressure, and water and electrical hookups should be performed. The repair and evaluation of some instruments can be done by means of a computer modem connection from a remote location. Malfunctioning components can be identified and replaced rapidly. Should malfunctions occur, timely access has become increasingly available as the number of laser instruments has increased.

Developing Instrumentation

Ongoing research using the tunable free-electron laser promises to provide basic data for new lasers that may be useful in medicine. Photobiologic interaction of laser light and drugs, such as those used with the dye laser, may also expand in the future. Other laser instruments under development include krypton, xenon, copper, and gold vapor lasers. Their usefulness, if any, in laparoscopy is yet to be demonstrated. Fiberoptical research in communication, aerospace, and defense should also benefit gynecologic endoscopy as it has in the past. Finally the increasing use of lasers in all aspects of our lives promises to make an increasing variety of new tools available to the endoscopist.

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16
Laser Laparoscopy for Infertility Surgery

DAN C. MARTIN, MICHAEL P. DIAMOND, and MARVIN A. YUSSMAN

Although lasers have been applied to many laparoscopic procedures by a small group of surgeons, their widespread use is needed to confirm that they can be mastered by more than this select group. The lasers used in operative laparoscopy are highly predictable instruments for precise and repeatable tissue destruction. Coagulation, vaporization, or excision of a lesion can be performed with an excellent anticipation of the tissue effect (Fig. 16-1). In addition, lasers coagulate the residual tissue sufficiently for hemostasis in most situations.

Lasers have been used in macroscopic[1] and subcellular[2] surgery since the 1960s. Kaplan et al.[3] reported on the first use of the carbon dioxide (CO_2) laser in gynecology. Bellina discussed the use of the CO_2 laser in gynecologic malignancy[4] and in reconstructive pelvic surgery.[5] Subsequently, single puncture CO_2 laparoscopic equipment was developed by Bruhat et al.;[6] Tadir et al.[7] developed second puncture applications and Daniell and Pittaway[8] popularized laparoscopic use in the United States. Keye and Dixon[9] studied the argon laser and Lomano[10] the neodymium:yttrium aluminum garnet (Nd:YAG) laser. More recently, Daniell et al.[11] worked with the 532 nm potassium titanyl phosphate (KTP) laser.

Laser Types

In choosing between lasers, the surgeon should be aware of their various characteristics and the results one can expect (see Chap. 15). The intrinsic depths of penetration for the lasers were discussed in Chapter 14. The 0.1 mm penetration of a CO_2 laser is responsible for the "what you see is what you get" biologic effect. The deeper penetration of the other lasers is responsible for their ability to coagulate without disrupting the surface at low power density. The depth of penetration is useful but does not predict the depth of coagulation. Coagulation is determined by the penetration, the time of exposure, the power density, and the tissue type. Thus the effective depth of coagulation of the argon and KTP lasers appears to be about 2 mm for endometriosis (W. Keye and P. Hertzman, personal communication). The Nd:YAG laser coagulates 1.0–4.4 mm when cutting liver with a noncontact fiber.[12] However, at high power densities the argon, KTP, and Nd:YAG lasers more closely approximate the biologic effect of the CO_2 laser. When high power density (3,500–17,500 watt/cm^2) vaporization is used with the Nd:YAG laser, the lateral coagulation decreases to 0.3–0.8 mm,[12] which is equivalent

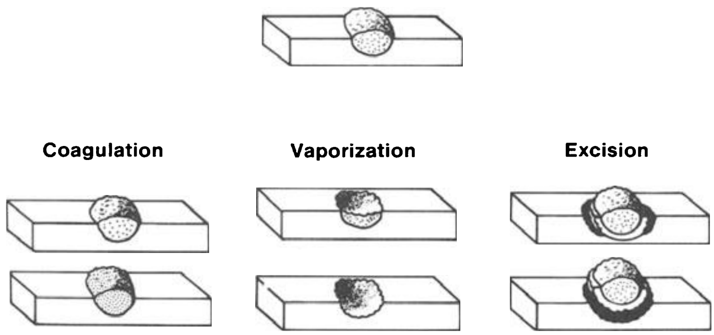

FIGURE 16-1. Lasers can be controlled to produce coagulation, vaporization, and excision. Coagulation by penetration is limited to a depth of 0.4–4.2 mm for argon, KTP, and Nd:YAG lasers. Coagulation past this depth is related to thermal injury. Vaporization utilizes a moderate power density to vaporize the lesion in its entirety. Excision makes use of higher power densities to vaporize the perimeter of the lesion while preserving the lesion itself for removal and histologic study. (From Martin DC, ed: Intra-abdominal Laser Surgery, 2nd ed. Resurge Press, Memphis, in preparation.)

to the depth of coagulation for the CO_2 laser at 500 watts/cm^2 in the continuous or repeat pulse mode.[13]

Additionally, focusing with a lens creates different beam characteristics than those from transmission out of the end of a fiber or off the end of a sapphire tip. Lenses focus beams to theoretically small spot sizes. Clinically useful spot sizes are generally no smaller than 0.2 mm. However, the actual spot size at the focal point is larger than the theoretical size and is held over a longer length. This longer length may be more accurately discussed in terms of depth of field[14] (Fig. 16-2). In this zone, the spot size and power density are relatively constant. Although the 125 mm lens for the hand-held CO_2 attachment produces a 0.2 mm spot size, its depth of field is only 2–5 mm. However, laparoscopes produce a spot size of 0.6–1.2 mm with depth of field as great as 5 cm.

Fibers deliver the beam as a constantly defocusing beam with a maximum power density at the tip of the fiber. (Fig. 16-3). Vaporization is performed in the immediate vicinity of the fiber tip where the power density is high. The power density rapidly decreases past this point into a zone of coagula-

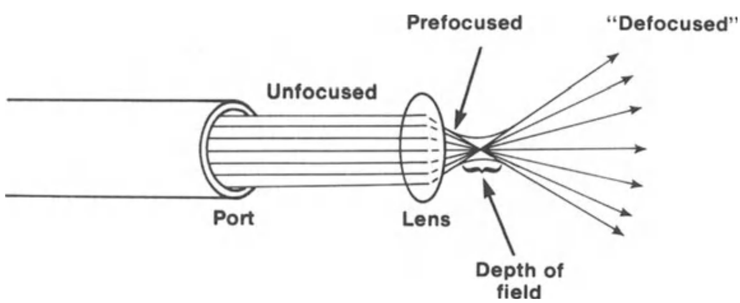

FIGURE 16-2. Laser exits from its port and is focused by a lens to a theoretical focal point. Depending on the lens characteristics and focal length, there is a distance on either side of the focal point in which the spot size and power density remains relatively constant. It may be spoken of as the depth of field of the system. (From Martin DC, ed: Intra-abdominal Laser Surgery, 2nd ed., Resurge Press, Memphis, in preparation.)

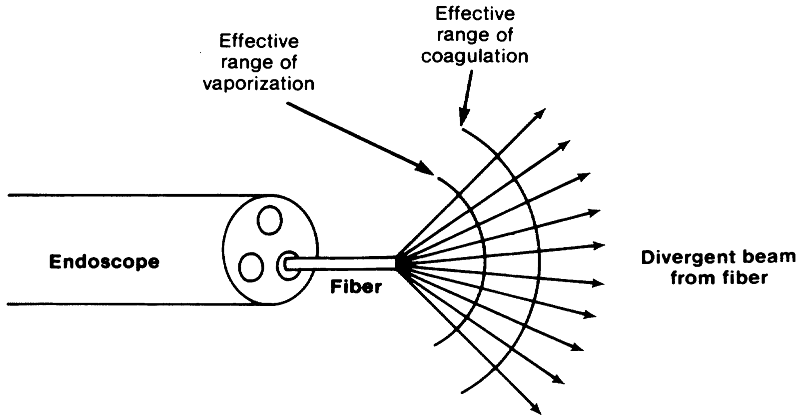

FIGURE 16-3. As the laser beam exits from a fiber, it diverges rapidly. At high power density, vaporization is possible in the vicinity of the fiber. Past this point, coagulation occurs. At far distances, greater than 1–2 cm, the power density has decreased below the threshold of coagulation. (From Martin DC, ed: Intra-abdominal Laser Surgery, 2nd ed. Resurge Press, Memphis, in preparation.)

tion. Past the zone of coagulation there is only heating and no irreversible thermal damage. This rapid defocus increases the need to stay close to the tip and, at the same time, provides protection to distant tissue. A beam coming off the end of a sapphire tip diffuses even more rapidly. The sapphire tips must be used in a contact mode.

CO_2 Laser

CO_2 lasers destroy tissue by vaporization. Larger spot sizes are used to vaporize the entire lesion and to increase hemostasis. Excision requires small spot sizes to vaporize the perimeter of tissue in a fashion similar to cutting with a knife. Excision preserves the tissue so that it can be examined histologically.

The heat created at the base of the vaporization crater (Fig. 16-4) is determined by the type of tissue vaporized. The temperature is generally limited to 100°C for water and around 200°C for fat. However, with lower power densities, tissue desiccation may occur before vaporization, producing dry tissue, which vaporizes at higher temperatures. At the extreme, this desiccated tissue is carbonized before vaporization. Carbon vaporizes at temperatures in excess of 1200°C.

The hemostatic property is related to coagulation of the residual tissue. It is a function of the intrinsic penetration of the laser and of the time of exposure to the heat of vaporization. Heat produces a zone of thermal coagulation. At distances beyond this zone, tissue is heated but remains viable. High power densities and rapid excision techniques limit thermal damage to 40–400 μm. Slower techniques can produce a spread of 300–700 μm. Attempts to vaporize desiccated tissue or carbon can raise the tissue temperature and result in thermal necrosis of up to 2700 μm.[13] Thermal coagulation of 300–700 μm is useful for hemostatic surgery of the cervix and for myomectomy but can be harmful near ureters and the bowel. These depths of coagulation with the laser are compared with up to 5 cm for unipolar current,[15,16] 3 mm for the thermal coagulator,[17] and 2–5 mm for the bipolar coagulator.[18] Because of the relatively limited intrinsic depth of penetration, the CO_2 laser may be used in short pulses of high power density to vaporize endometriosis or incise adhesions with the knowledge that the depth of destruction will be what is seen (i.e., "what you

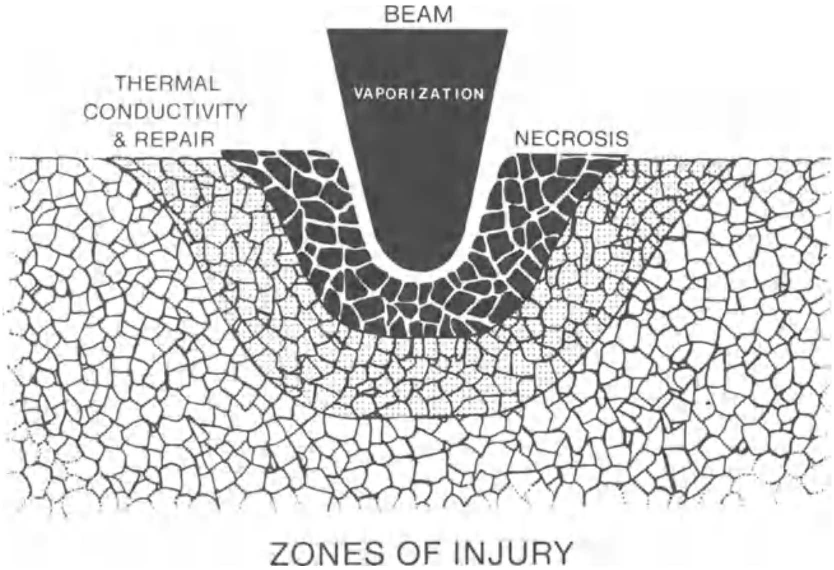

FIGURE 16-4. Energy densities greater than the threshold of vaporization created a vaporized crater surrounded by a zone of necrotic tissue. This necrotic zone is determined by the depth of penetration of the laser and the depth of thermal coagulation related to heat in the crater. (From Martin DC, ed. Intra-abdominal Laser Surgery. Resurge Press, Memphis, 1986.)

see is what you get"). On the other hand, when unipolar coagulators are used, the depth of destruction may be deep enough for delayed perforation.[16,19,20] At the same time, thermal, bipolar, and laser coagulators may be limited to 2–5 mm and thus would be inadequate for destruction of larger lesions.

The depth of the vaporization crater is controlled by power density, exposure time, and back stops.[21–23] This control is learned both in the laboratory and in the operating room. Preliminary learning should occur during "hands on" courses as well as in the surgeon's own operating room. Preceptorships and assisting experienced surgeons are a great help in the surgeon's education.

Control with the CO_2 laser involves the use of techniques that maintain high peak power densities while lowering the average power density. These techniques include using superpulse, chopped waves, and repeat pulse. The spot size should be kept small and the laser used at its focal point. The combination of a 0.6 mm spot size, 20–50 watts, and a repeat pulse of 0.05–0.10 second duration at a frequency of 2 pulses per second can generally be controlled. Superpulse and chopped waves create higher peak power density and limit the thermal destruction. Control can be maintained with these waves by decreasing the repetition rate, the pulse width, or both.

Although the primary safety control for limiting the depth of penetration is familiarity with the techniques and the equipment, backup safety precautions are advisable. Backstops include water solutions, rods, and the use of relatively resistant tissue. Heparinized Ringer's solution has been useful. Sandblasted or treated metal rods can be placed through auxiliary puncture sites. In addition, the wall of a hydrosalpinx can be used as its own backstop. When choosing an intended tissue for use as a backstop, avascular peritoneum has a greater margin of safety than vascular peritoneum, ureter, or bowel.

The helium neon (HeNe) beam serves as an aiming device. When this beam cannot be seen, one can assume that it is aimed at something not intended. The most common reason the beam disappears is smoke and other debris in the laser channel. Constant insufflation through this channel keeps the smoke out of the way and protects the coupler lens. However, the more dangerous obstructors of the beam are the bowel and vessels. In addition, uterus, tubes, and ovaries can be inadvertently damaged by the laser. The single puncture instruments will more commonly aim at bowel. The second puncture instruments will more commonly aim at uterus, tubes, or ovaries. Other common causes of loss of the HeNe beam include a misaligned beam, disconnection of the insufflation line, air leak at the coupler, and fogged mirrors. Hollow waveguides for the CO_2 laser, which can decrease these problems, have been developed and are being refined.[24]

The CO_2 laser smoke increases with both decreasing power density and the use of vaporization techniques. This smoke has toxicity and mutagenicity similar to electrocautery and cigarette smoke.[25–28] Such smoke should be minimized and removed. High power densities and excisional techniques decrease the smoke and carbon produced. Superpulse technique increases the efficiency of excision and minimizes the amount of smoke plume produced. Coagulation by use of the fiber-transmitted lasers, with removal of no tissue, leaves the most ablated tissue behind but decreases the smoke plume.

Prior to using lasers with the laparoscope, it is helpful for the surgeon to have experience with operative laparoscopy and the microsurgical laser (Fig. 16-5). Much of the work through the laparoscope is based on microsurgical laser techniques. These laparotomy techniques have been shown to shorten operating time, increase control of tissue, and decrease blood loss.[21,23,29–32] There are also certain operations where the short focal length and wide range of power densities of the hand-held laser are used at laparotomy.[14,33] The hand-held attachment is particularly useful when a rapid change between power density ranges is needed in excising myomas and in removing endometriosis from densely scarred areas.

For the operating laparoscope, the power density is decreased by interaction with the laparoscope channel[34–36] (Table 16-1). This decrease has been measured at up to 52%. Therefore the surgeon should anticipate the need for an increased power output compared with that for laparotomy techniques.

Argon, KTP, and Nd:YAG Lasers

In contrast to the CO_2 laser, in which the energy is most commonly transmitted

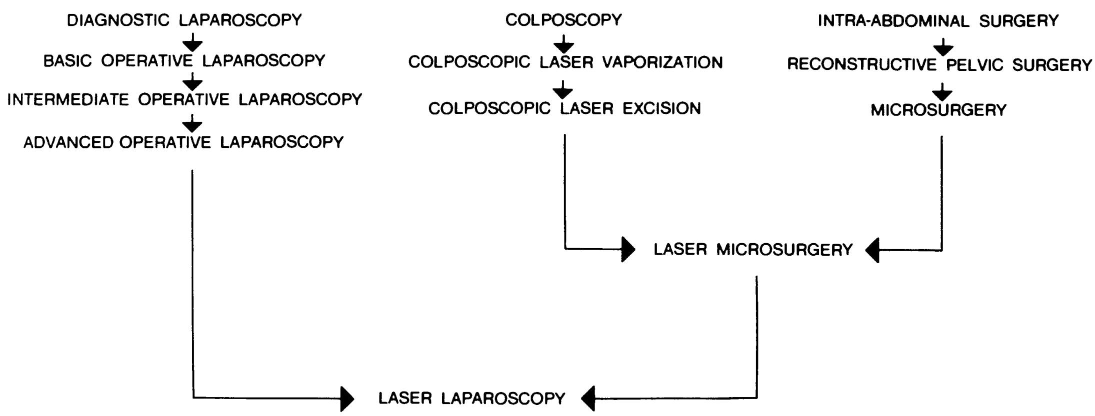

FIGURE 16-5. Significant experience in operative laparoscopy, colposcopic laser excision and microlaser surgery is needed before mastering laser laparoscopy. Surgeons should be diligent not to take shortcuts in this path. (From Martin DC, ed: Intra-abdominal Laser Surgery. Resurge Press, Memphis, 1986.)

TABLE 16-1. Power density of CO_2 lasers

Channel size	Decrease in power density (%)
8 mm diameter	8
5.6 mm diameter	15
4 × 6 mm oval	52

Note that the density decreases owing to interaction with the channel.[36]

through air in long tubes to the target tissue, the energy of the argon, KTP, and Nd:YAG lasers are transmitted via a fiber. Compared with the CO_2 laser, these lasers have had less use in gynecologic surgery. All three of the fiber-transmitted lasers have now been used in the treatment of intraabdominal pathology, with early reports describing their use.

The argon and KTP lasers are both within the visible wavelength, and thus use of a HeNe aiming beam is not required. The argon laser emits two principle wavelengths, at 488.0 and 514.5 nm. The KTP is a frequency-doubled YAG laser with a 532 nm wavelength and thus is similar to the argon laser beam. These wavelengths are in the blue or greenish portions of the spectrum and are preferentially absorbed by reddish pigments. It is for this reason that it was thought they would be very useful in the treatment of endometriosis. Keye and Dixon[9] demonstrated the ability to ablate experimentally induced endometrosis in rabbits using the argon laser. Both the argon and KTP lasers have also been used to treat endometriosis as well as a variety of other types of pelvic pathology. The Nd:YAG laser is a 1064 nm infrared laser and has seen the greatest use in gynecologic surgery for endometrial ablation.[10] However, it has also been used as a bare fiber for ablation of pelvic endometriosis[37] and with sapphire tips in the treatment of a variety of abdominal pathology.[12] At high power density, all of these lasers appear to have biologic effects and uses similar to those of a CO_2 laser.

An additional concern for the surgeon and the other operating room personnel is the increased potential for ocular damage with the use of fiber lasers. In contrast to the beam of the CO_2 laser, which is stopped by glass or plastic, regular eyeglasses will not protect the viewer from the argon, KTP, or Nd:YAG laser beams. Specifically designed protective eyewear varies from one laser to the other and is directly related to the wavelength of the beam itself. When these lasers are used via laparoscopy, a lens filter or mechanical shutter is placed over the viewing channel of the operating laparoscope.

Laser Delivery Systems

Lasers can be delivered to the target tissue through hollow tubes or fibers using single or second puncture equipment. Flexible fibers can change the direction of the beam near the target site. Mirrors can be used with nonflexible equipment. Alternately, the tissue itself can be moved into the direction of the beam rather than moving the beam to the target.

Single puncture equipment has been the easiest to teach and to learn. With single puncture equipment, the beam is always directly ahead of the operator in a predictable zone. This technique has been very useful for ablation with the CO_2 laser and for coagulation with the Nd:YAG, argon, and KTP lasers. However, Borten and Friedman[38] noted that instruments used through the operating channel decrease the field of vision, resulting in an increased chance of tissue being hidden and damaged. As previously discussed, a unique variation when using the CO_2 laser is that the bowel can cover the laser exit port but not be seen through the optical port. In this situation the HeNe aiming beam disappears. When the HeNe beam is not seen with a single puncture laser laparoscope, the most dangerous possibilities are bowel or vessels in the path of the beam. The most common occurrence is lack of insufflation pressure and smoke plume backing up the laser channel.

The fiber of the fiber laser is introduced into the operative field by passing it through the operating channel of the viewing laparoscope, through a second puncture probe, or through a needle (such as the aspiration needles used for in-vitro fertilization attempts). Regardless of the manner in which the fiber is introduced, it is brought into the near proximity of or direct apposition to the tissue to be treated. The laser can then be activated to vaporize or coagulate the underlying tissue. Because of the greater depth of penetration with the fiber lasers, there is increased concern regarding the immediately underlying structures. However, the rapid defocus decreases the need for a backstop when compared to the CO_2 laser. Despite the concern for damage to underlying structures, the argon and KTP lasers have been used to treat endometriosis on both the bowel and the bladder.

Because of the ease with which the fiber can be passed into the operative field, it is often easier to use the fibers than the rigid arms of a CO_2 laser. However, the argon, KTP, and Nd:YAG lasers may require a source of running water for cooling. They may also require special electricity sources, and thus their use is limited to operating rooms with these modifications.

Coagulation with fiber lasers produces less smoke and laser plume than vaporization with the CO_2 laser. There is less need to exchange the pneumoperitoneum in cases performed with the use of the fiber lasers. However, with the introduction of the new high flow insufflators, this complication has become less of a problem for all lasers (see Chap. 2).

Another modification of the use of fiber lasers at laparoscopy has been the introduction of the sapphire tips.[12] These tips can be applied to any of the fiber lasers but have primarily been used in conjunction with the Nd:YAG laser. They alter the properties of the laser beam such that it can have a vaporization effect approaching that of the CO_2 laser. In contrast to the bare fibers, which can be used either in a "no-touch" or a "touch" technique, the sapphire tips must be used in a "touch" technique—to maintain the tissue effect and to prevent destruction of the tips themselves. A variety of configurations of sapphire tips are available, each of which has a different effect on tissue. These tips are being studied in the performance of gynecologic procedures.

Second puncture probes for the CO_2 laser have a shorter focal length and produce higher power densities. Although it is a more difficult insertion site to use, the higher power density decreases residual tissue damage and appears to increase the ability to resect and dissect tissue planes.[18,22,39,40] One of the main disadvantages of the second puncture probes is the inability to be certain of the distal targets when the primary target is penetrated. To enhance safety, pulse modes are frequently used to limit penetration. In addition, the probe, the target, and any distal tissue are kept in the visual field as much as possible. However, unintended proximal targets that

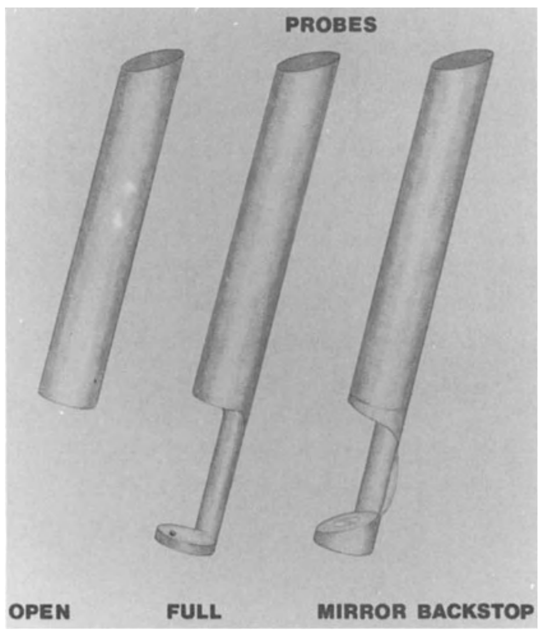

FIGURE 16-6. Second puncture probes have interchangeable tips. The beam projects straight ahead of the open-ended probe and is stopped by the pullback stop of the backstop probe. The mirror backstop reflects the beam at a 90° angle. (From Martin DC, ed: Intra-abdominal Laser Surgery. Resurge Press, Memphis, 1986.)

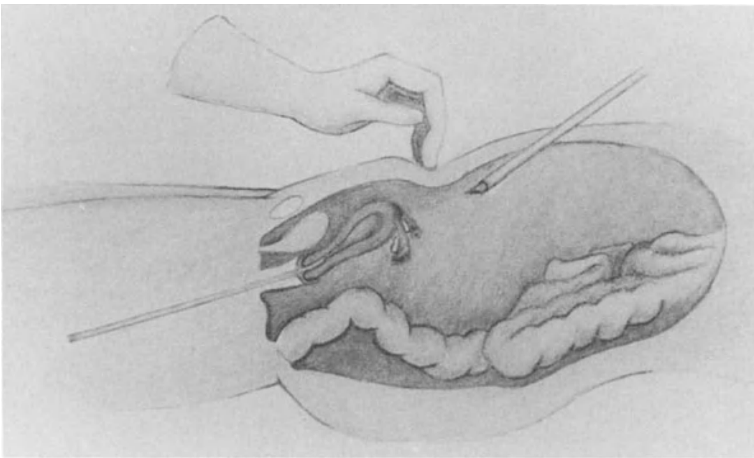

FIGURE 16-7. Second puncture probes should be placed high enough to avoid the uterus and low enough to avoid the laparoscope. (From Martin DC, ed: Intraabdominal Laser Surgery. Resurge Press, Memphis, 1986.)

have been damaged are the uterus, tubes, and ovaries. Bowel, as a proximal target, has not been a problem with the second puncture but may pose a problem as an unintended distal target.

The CO_2 second puncture equipment has changeable tips (Fig. 16-6). The three tips currently available include an open-ended probe, backstop probe, and mirrored probe. The open-ended probe is the one most commonly used after adequate clinical experience. The backstop probe provides extra insurance in limiting the depth of penetration when lysing adhesions. With the backstop probe, there is minimal worry about unseen distal targets. The mirrored probes have been more interesting than useful. Newer refinements are currently available that may increase the utility of the mirrored backstops. When placing second puncture probes, the insertion is generally higher than that used for sterilization (Fig. 16-7).

Laser Safety

With the use of any type of laser surgical equipment, safety is of major concern. All surgeons must be diligent in their efforts to make certain there are appropriate indications for laser surgery and that they themselves are adequately skilled in the use of laser equipment. Otherwise, patients may be exposed to unnecessary risk.[41] In addition, special attention to safety should precede the use of any new equipment or newly developed techniques.[42] CO_2 surgical lasers, as stated previously, have a class IV rating. The high voltage of the power supply can be hazardous.[43]

The invisible energy emitted by the optical resonating chamber of the CO_2 laser is capable of causing severe tissue destruction and of igniting flammable materials. (The reader is referred to Chapter 14 for a further discussion of laser physics.) Rigid, but at the same time common sense, safety precautions must be exercised with use of the laser. The most obvious of these precautions is to make sure the individual who is to use the instrument is fully aware of its potential hazard and thoroughly familiar with its operation. The surgeon must be fully trained in the use and safety measures of the laser and must in addition assume responsibility for the safety of all individuals present in the operating suite. Apart from the surgeon, there must be at least one fully trained technician in the operating room whose duty is to operate the laser while the surgeon gives full concentration to the operative procedure. This individual also acts as the backup safety inspector for the operating room staff and therefore should be someone other than the circulating nurse[44] (see Chap. 13).

Special glasses must be used with the CO_2 laser to prevent accidental injury to the eye.

Goggles or glasses with side protectors are advisable for anyone who may be exposed to the direct or reflected beam. When the laser system is introduced into the abdomen during endoscopy and the beam properly filtered, there is no external exposure of the CO_2 beam until the equipment is removed from the abdomen and fired externally. Failure to comply with CO_2 safety standards can result in significant and permanent ocular damage, as this laser can cause corneal lacerations.[45]

Ball[45] recommended formation of a special hospital committee to plan, "implement and evaluate, on a continual basis, safety measures used during laser surgery." This committee is responsible for establishing written guidelines to ensure appropriate laser safety practices. Proper credentialing of physicians involved in any laser surgery is a fundamental element of laser safety. Chapter 23 provides basic guidelines for this process.

Prior to any operative laser procedure, evaluation of laser equipment must be a "routine" part of the laser safety protocol. Appropriate laser beam alignment must be determined as well as assessment of power output from the projected lowest to the highest power density. A proper checklist should include laser warning signs at all operating suite entrances, appropriate ocular safety precautions, avoidance of any preparatory solution containing alcohol or acetone, ready access to fire extinguishers such as the Halon type, proper assessment of electrical cords, and inspection of operative equipment such as backstops and fume evacuation apparatus (see Table 16-2). The operator must make it a habit to request that the laser be on standby whenever it is not being fired.

Use of the CO_2 laser during laparotomy requires care to prevent reflection of the beam off metallic instruments in the operating field. When the laser is in use, instruments that have been properly brushed or blackened to modify reflection and absorption are preferable. Even a defocused beam is capable of causing a significant burn.

Inasmuch as the CO_2 laser beam is emitted in the infrared electromagnetic spectrum, it is invisible. The HeNe beam, which is in the visible range, always acts as the targeting beam. With use of either an endoscopic or a hand-held laser, a test of the alignment of the He-Ne and the CO_2 beams must be made before any procedure is begun. The test usually is accomplished by focusing the He-Ne beam on a wet tongue blade or on some other nonflammable substance and test-firing the laser. The CO_2 beam should strike at the point of the HeNe beam.

TABLE 16-2. CO_2 laser equipment evaluation

Check beam alignment
Check controlling power output
Warning signs on door
Ocular safety
Avoid alcohol or acetone preparation solutions (flammable)
Fire extinguisher
Backstops
Fume evacuation apparatus

The laser should not be used in the presence of volatile substances such as alcohol, hydrocarbon solvents, or flammable anesthetic agents (see Chap. 13). One should use extreme caution to prevent fire caused by impact of the beam on flammable materials such as dry laparotomy pads. The pedal that activates the laser should be kept housed to prevent accidental activation. It is inadvisable to place pedals that activate other instruments next to the laser pedal.

Plume created by the vaporization of tissue is hazardous to the respiratory system.[18,25–27] In addition, it may be the mechanism of dispersal of viral particles such as the papillomavirus.[46] Face masks do not protect against these viral particles. Therefore a properly operating mechanical evacuation system must be used whenever laser plume is created with either endoscopic or open laparotomy surgical procedures. Such plume must not be allowed to enter the hospital vacuum system in order to prevent massive contamination.

The U.S. Federal Performance Standards for a class IV laser product require the presence of a protective housing for the laser beam, a master key switch, an emission indicator, a beam shutter, a power monitor, a remote interlock system connection, and proper labeling.

Operation of the CO_2 Laser

For the purposes of this chapter, the Sharplan 1060 CO_2 laser (Laser Industries, Tel Aviv, Israel), will be used as an example. Prior to operation of the laser, the operator must be familiar with the manufacturer's operating manual as well as the laser safety training manuals.[47–51] The control panel is shown in Figure 16-8. The same principles are applicable to the Sharplan 1060 as to other equivalent CO_2 lasers. When the key is inserted into the keyswitch of the control panel of the CO_2 laser and turned clockwise, electrical power is supplied to the unit's primary subsystems: the HeNe aiming beam, the STATUS indicators, and a motorized column on newer models. The key should be removed whenever the system is left unattended. The POWER ON indicator illuminates after the keyswitch is turned and remains illuminated until the keyswitch is turned off.

The ON/STBY key has a dual function. The on function relates to the first activation following keyswitch turn-on. Depressing the same key subsequently places the unit in the standby mode. In STBY, the footswitch is disabled. When pressed, the OFF key shuts off the electrical power to all except the primary subsystems.

High power laser operation, with a minimum power of 2.0 watts, is activated by default. The low power key is used for setting the system to operate between 0.1 and 1.0 watts. The SUPER PULSE key sets the system to operate in the "super pulse" operation mode. In this mode, the laser beam is emitted in a train of very narrow pulse width, high peak power "super pulses." The super pulse repetition rate is adjusted electronically to obtain the desired average power. The power display shows the super pulse average power, which ranges from 0.1 to 15 watts. Other modes of operation are obtained by pressing the appropriate key, usually indicated as continuous, single pulse, or repeat pulse. The duration of each pulse is determined by setting appropriate duration and frequency adjustments. The power is displayed on an appropriate gauge or digital LED display. A power increase and decrease key or adjustment knob is used to set the desired power level.

A HeNe beam intensity control permits the HeNe aiming beam to be either fully emitted (FULL), reduced to half power (MED), fully blocked (OFF), or blinking. When illuminated, the laser emission indicator shows that CO_2 laser emission is in

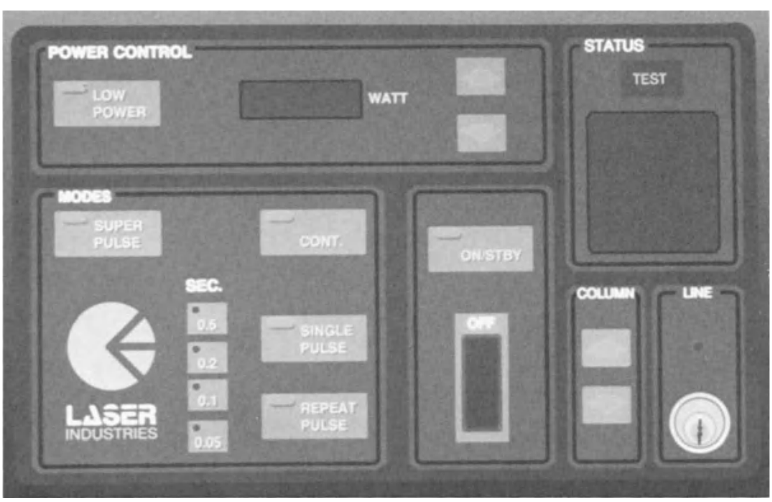

FIGURE 16-8. Control panel of the Sharplan 1060 CO_2 laser. (Courtesy of Sharplan Lasers, Inc., Allendale, New Jersey).

process. The CO_2 laser beam shutter operates in conjunction with the laser emission indicator. The shutter prevents beam emission and is activated by the footswitch only when the system is in one of its modes of operation.

Prior to turning the unit on, one should ensure that it is plugged into the appropriate power source. The laser gas mixture and the dry nitrogen gas cylinder valves are slowly opened. The laser gas mixture is composed of 4.5% carbon dioxide, 13.5% nitrogen, and approximately 82% helium.

Each unit will have a "self-test system" operating when the unit is initially activated. The surgeon should be familiar with the specific tests being performed by the unit. The following tests are made on the Sharplan 1060 unit, which is representative of indicators on other units.

1. Insufficient gas line pressure, indicating either an empty gas cylinder or a closed valve.
2. Temperature indicator, showing overheating in the laser head, symptomatic of insufficient cooling.
3. Cabinet temperature indicator to show overheating in the main cabinet, symptomatic of a high voltage problem.
4. Short circuit indicator.
5. Indicator of excess current in the high voltage system.
6. Shutter failure indicator.

Other standard monitors to be checked on a routine basis and during situations in which malfunctions may occur include the following.

1. Nitrogen pressure gauge indicating nitrogen gas pressure from the gas cylinder.
2. Laser gas mixture pressure gauge indicating gas pressure from the gas cylinder.
3. External ground.
4. Dry nitrogen flowmeter to set nitrogen flow rate.
5. Footswitch connector.
6. Remote switch connection when using an external interlock control, as on the operating room door.
7. Coolant level indicator window showing level of water.

One should wait about 15 seconds to allow the system to stabilize, and then one of the nine modes of operation is selected. At this point, the alignment of the HeNe beam in relation to the CO_2 beam should be checked as described earlier. At the time this check is made, one should also note that the nitrogen flows when the footswitch is activated.

If the single or repeat pulse power mode is selected, the operator should set the desired pulse duration and interval. The power should be set after the "turn on" procedure. In units with a high and a low power selection, the appropriate selection should be made. The power selection should be determined with the system in the "standby" mode. The power settings can be changed whenever desired, provided the beam is not being emitted. On the new digital models, the power is set by depressing the appropriate key to the approximate setting, then intermittently depressing the key to obtain the specific setting. Once the mode has been selected and the power level set, the system is ready to emit the laser beam whenever the footswitch is depressed.

Whenever there is a short pause in operation, the standby key should be pressed. This step cancels the power delivery mode and disables the footswitch but preserves the power settings. The system is returned to a power delivery mode by pressing the ON key again. This procedure should be followed whenever the surgeon's attention is diverted from the operating field.

When a procedure is terminated, the unit can be turned off by pressing an OFF key or by turning the keyswitch to the OFF position. After turning off the unit, the gas cylinder valves must be closed.

Each unit should come with a specific troubleshooting guide. However, some general rules can be followed. Access to the high voltage cabinet should be avoided and repairs in this area referred to the appropriate "in-house" or company technical support. In any event, one should recall that the high voltage capacitors in the unit take some time to discharge and that the unit retains dangerously high voltage for several minutes after it has been switched off.

If the laser temperature rises, check the water level or check for a blown fuse. If the cabinet temperature rises or a short circuit message should occur, the system should be shut down and the unit referred to the company for a check of the high voltage system. Other problems that should be referred to the company representative are shutter failure, failure of ignition, failure to reach desired power setting, failure of HeNe and CO_2 alignment, and footswitch failure.

If no HeNe indicator beam can be seen, the HeNe shutter should be checked. If power fails to come on when plugged in, the power from the outlet should be checked. Usually a tripped circuit breaker is the cause. If the power is on but no mode can be selected, the appropriate fuse should be inspected. If the gas level is low, one should verify that the gas cylinder valve is opened, the cylinder is empty, or the regulator is set too low.

If power change does not occur when appropriate keys are activated, the appropriate fuse should be inspected; and any gas conservation mechanism that may have been activated must be checked. The laser gas mixture cylinder may need to be replaced. If these measures do not eliminate the problem, the company should be contacted. If the laser fails to activate when the footswitch is depressed, usually it is in the "standby" mode or the footswitch is improperly connected.

Safety and Operation of the Argon and KTP Lasers

Some additional precautions and procedures are necessary with the use of either the argon or the KTP laser. When operating these lasers, one should remember that the electromagnetic wave is in the visible spectrum and will penetrate clear glass obstructions (see Chap. 14). The spectrum provides differential absorption by darker pigments and blood. All treatment room windows must be covered with opaque material when the argon or KTP laser is in operation. All personnel must wear protective eyewear (Table 16-3). For the argon or KTP laser, filters should be orange or red. Inadequate filtering of this laser beam, which is in the visible light spectrum, can result in retinal burns—the degree of retinal damage being directly proportional to the power of the beam as well as to the duration of exposure. Inadvertent irradiation of tissue adjacent to the target tissue can result in laser burn with the argon or KTP laser as well as the CO_2 laser. The operator must avoid ignition of flammable materials and make sure that only nonflammable preparatory solutions are used. The laser plume should be evacuated with the argon or KTP laser in a manner similar to that with the CO_2 laser. There must be a similar concern to prevent reflection of the beam from instruments used during the endoscopic or open laparotomy procedures. The patient should wear protective eyewear similar to that used by the operating room personnel. It should go without saying that electrical hazards must be avoided; therefore all laser equipment must be carefully inspected prior to any surgical procedure (Table 16-4).

The argon and KTP lasers are water-

TABLE 16-3. Types of eye protection used with various lasers

Laser	Goggles or glasses
CO_2	Clear plastic or glass
Nd:YAG	Green (Nd:YAG)
Argon	Orange (argon)
Krypton (violet)	Orange (argon)

TABLE 16-4. Argon and KTP laser equipment evaluation

Check controlling power output
Warning signs on doors
Ocular safety (orange and red filter)
Avoid alcohol or acetone preparation solution
Fire extinguisher

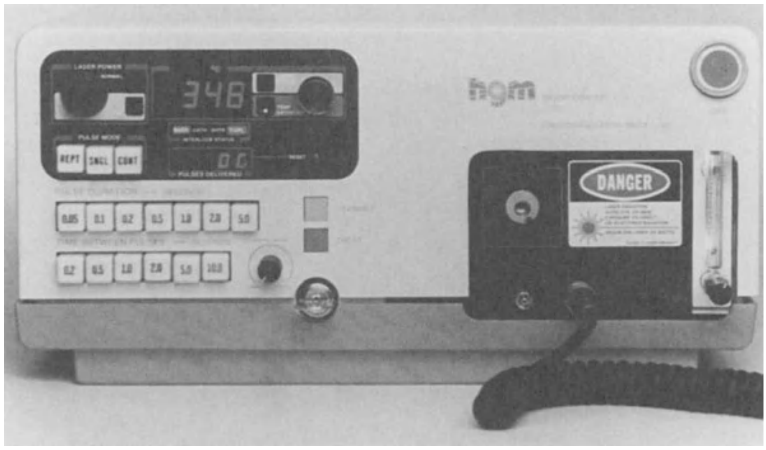

FIGURE 16-9. Control panel of the HGM argon laser. (Courtesy of HGM Medical Laser Systems, Inc., Salt Lake City, Utah).

cooled. They must therefore have a water source and drain. These external hoses are connected to extension hoses at the rear of the laser. The incoming cooling water, from a regular cold water tap, must be connected through a standard hose valve. Although not required, filters are recommended.

Before starting the argon or KTP laser, the water hoses should be checked for both incoming and drain openings. The main circuit breaker should be on. The argon laser manufactured by HGM Medical Laser Systems (Salt Lake City, Utah) will be used as an example. The control panel for the argon laser is shown in Figure 16-9 and the control panel for the KTP-532 laser (Laserscope, San Jose, CA) is shown in Figure 16-10. In these systems, the footswitch cable is connected at the front panel. The keyswitch is turned on first. The probe, catheter, or fiberoptic cable is then plugged into the laser aperture. The treatment power and aiming beam controls are set at MINIMUM. After these conditions are met, the ON switch is pressed and the laser will "power up." After a short period, the laser tube will turn on, which is signified by illumination of the "standby" lamp. By depressing the "treat" switch, the standby lamp shuts off and the treat lamp illuminates. The aiming beam is then visible through the cable. The aiming beam intensity can be varied from the panel. This beam allows the user to locate the beam on the operative field. The operator may now control the treatment beam by using the footswitch. The mode is set for single pulse, repetitive pulses, or continuous pulse. The power is adjusted using the appropriate control. The output power of the treatment delivery system is indicated on a display on the front panel. The external power is measured. With protective eyewear in place and the laser in the treat mode, the treatment power adjustment knob is set to minimum. The tip of the hand probe is placed approxi-

FIGURE 16-10. Control panel of the Laserscope KTP/532 laser. (Courtesy of Laserscope, San Jose, California.)

mately 1/8 inch away from the detector window. The continuous mode is set and the footswitch depressed. The power can be slowly increased to the desired setting. The laser is now ready for surgical use. In the internal power measurement, the meter continuously reads the output of the laser tube via the setting of the treatment power control. This power reading should not be used as a substitute for the actual power measurement achieved through the steps previously outlined.

Other precautions unique to the argon laser are indicators that will illuminate if the external water pressure is too low or too high, the fiberoptic output device is not inserted into the laser aperture, or the laser's internal shutter mechanism fails to function properly.

"Troubleshooting" the argon laser is similar to that for the CO_2 laser described earlier. If the system will not turn on, one should check the external power source, ensure that the keyswitch is on, the footswitch connected, and the ON/OFF switch properly depressed. If the unit is working but various indicator lights are out one may assume that the problem is with the indicator bulbs, which should be replaced by a service representative. If the standby lamp will not illuminate, one should wait, be sure the fiberoptic probe is inserted into the laser aperture, and check to see that the water pressure is appropriate. To check if the shutter mechanism is operating, the footswitch is depressed repeatedly with the unit in the CONT mode. If the system intermittently shuts down and comes back on, one should check for fluctuating water pressure or a loose water hose connection.

If the treatment power output is low, one needs to determine if the sealing lens should be cleaned or replaced, the detector window cleaned, or the fiberoptic cable replaced. To check power output of the cable, the laser is set in EXT and the probe is fired into the detector window with the laser set in SNGL for 1 second.

If no power output is obtained when the footswitch is depressed, one should verify that the laser is in standby prior to putting the laser into treatment mode. Shutter mechanism malfunction can be detected by depressing the footswitch repeatedly with the unit in CONT mode.

If there is no compressed gas flow, one should verify that the source is connected, turned on, and set to 50 psi. It is also important that the laser flowmeter is turned on, the catheter is plugged into the front panel, and the catheter has not been plugged.

Safety and the Neodymium:YAG Laser

The Nd:YAG laser has not been used extensively in gynecologic endoscopy. Its primary use is for endometrial ablation. The reader is referred to Chapter 19 for a further discussion of the use of the Nd:YAG laser. The operating surgeon and operating room personnel must be familiar with safety precautions for the Nd:YAG laser. Ocular safety apparatus should be in the blue-green spectrum and be capable of protecting the entire globe of the eye.[52] In a manner similar to that of the lasers described previously, windows should be appropriately covered and doors clearly demarcated to prevent accidental entry into the operating suite during laser operation. A similar concern for prevention of fire and use of nonflammable anesthetics should also be addressed.

Laser Treatment

Endometriosis

Endometriosis, as discussed in Chapter 17, is a potentially chronic and debilitating disease. Although medical suppression may transiently alleviate pain and help pregnancy rates, clinical recurrence of the disease should be anticipated.[53–55] For this reason, complete excision or destruction of endometriosis appears to be helpful in preventing long-term recurrence rates. This destruction or excision is limited to visible or palpable disease.[18,56,57] However, close scrutiny with "close-up" laparoscopy combined with careful palpation and "near laparoscopy" can be used to increase the number and variety of lesions seen and removed.[39,40,58–63]

The CO_2 laser is the one most commonly used for vaporization and excision.[8,18,21–24,34–36,39,40,64–74] Argon lasers,[9,65,75,76] Nd:YAG lasers,[37,77] and the KTP laser[11,78,79] have been used to coagulate and ablate lesions. Although fiber-equipped lasers have generally been used for superficial coagulation of surface disease, moderate and severe disease also have been treated. Buttram and Reiter[53,80] have questioned the value of coagulation and worry that it may lead to unrecognized deep damage. Although their concerns were related to the use of electrical current, these potential problems are expected to apply to any coagulation source and to coagulation secondary to the heat of laser vaporization if low power densities are used.[13] To Buttram's concerns can be added the problem that lesions thicker than the effective depth of coagulation will not be destroyed. This problem has been seen with bipolar coagulation in tubal sterilizations[81] and may result in unrecognized residual endometriosis.

Various argon and KTP lasers use power settings ranging from 0.5 to 16.0 watts. The fiber tip can be held approximately 1–2 cm from the peritoneal implants and the laser activated. Additionally, the surrounding peritoneum is also often coagulated because of the possibility of microscopic extension of the endometriosis from the visible implants. Alternatively, the fiber can be applied directly to the endometriosis, although it usually is not necessary. Implants on the bowel and bladder have also been treated. Because of greater depth of penetration when compared with the CO_2 laser, the length of time that the laser is in use at these sites must be minimized. Small endometriomas can be ablated in a fashion similar to treatment of peritoneal implants of endometriosis with use of either a "touch" or "no touch" technique.

Vaporization with the CO_2 laser is easier to learn than excision and, for small lesions, the most rapid to use. However, excess smoke and debris is created in vaporization of larger lesions. In addition, excision of small lesions is necessary for histologic confirmation when the appearance of these lesions is borderline.[39,40,59–63]

Either excision or vaporization with the CO_2 laser requires initial outlining of the lesions so that the margins can be identified. If the lesion is to be vaporized, the CO_2 laser is run across the entire lesion until healthy tissue is noted at the depth. This healthy tissue is most frequently described as being wet subcutaneous or fatty-appearing tissue. In excision, the perimeter of the lesion is vaporized in a knife-like fashion. The lesion is then lifted forward and the laser used to incise into healthy subcutaneous or fatty tissues. Deep cul-de-sac lesions can be palpated and excised to or through the vagina. Blunt dissection of deep planes also helps maintain control in certain situations. In particular, the ureter can frequently be bluntly pushed away from the lesions so that the laser is never aimed directly at it. If the ureter does not push away easily, it may be adherent to the endometriosis. After the lesion is completely excised, it is removed through the operating channel, the trocar sheath, a mini-incision, or the vagina and sent for histologic confirmation. The tissue may be too large to remove without morcellation (see Chaps. 2 and 3).

Carbon accumulation must be avoided as it may obscure the operating field both at the time of surgery and at subsequent laparoscopy.[18] Excision of these carbon areas at second-look laparoscopy shows that the carbon is peritonealized with few or no adhesions. A foreign body giant cell reaction similar to that seen around old suture is noted. When both carbon and endometriosis are in the same area, the carbon can be such a dominant finding that the endometriosis is not seen. Carbon is much easier to see than endometriosis in some of these situations. Therefore the carbon is removed with both lavage and pusher sponges. Heparinized Ringer's solution is used as a lavage and can be placed in and out, 30 ml at a time, or placed through a constant irrigation system such as the Irravac[69] or an Aquapurator.[82] Although the constant irrigation sources add one more piece of equipment to the operating table, they are very useful not only for removal of carbon and other debris but also for certain dissections.

Pusher sponges, used to remove adherent carbonized debris, are held tightly in toothed biopsy forceps and inserted as a unit with the laparoscope. If dropped, these sponges can fall behind the sigmoid colon, in which case the laparoscope table can be moved in "Trendelenburg" and "reverse Trendelenburg" positions as well as in a lateral tilt position. Lateral tilt moved the colon off the pusher sponge in one case.[18] The smoke itself can be removed by several suction devices. A simple system is to vaporize until the smoke obscures the field and then deflate the entire abdomen. The abdomen is subsequently reinsufflated. Rapid insufflation devices that decrease the time of insufflation have been previously described (see Chaps. 2 and 3).

Surface endometriosis and endometriomas of less than 5 mm are biopsied and the base vaporized or coagulated. Vaporization is continued at least to the level of white-appearing ovary. Histologic examination of residual adherent ovary has shown residual endometriosis past the grossly recognizable disease.

Endometriomas of 2–5 cm have been the easiest to enucleate. They are first opened with the laser, irrigated, and examined. The edge of the wall is then teased out and stripped in the same fashion as that used in nonlaser technique[35,83–86] (see Chaps. 6 and 17). A useful technique for developing the dissection plane has been to open the endometrioma at one point. The edge is grasped and the laser then used to make a second relaxing incision into healthy ovary. (Fig. 16-11). Pressure is placed through this second incision until the dissection plane is developed. This technique has been of significant use at the proximal ovarian margin. The margin (nearest the uteroovarian ligament) commonly tears and bleeds without this relaxing incision. Histologic examination of ovarian endometriosis has demonstrated that, although surface endometriosis and small endometriomas tend to involve the ovary in an irregular and unpredictable fashion, larger endometriomas are flattened, with active endometriosis seen only on the internal lining wall.[87] When endometriomas are greater than 5 cm, the procedure is long (up to 5 hours) and the dissection planes are difficult to recognize. The ovarian shell may collapse into the surgical zone, and complete resection is difficult to guarantee. In addition, these endometriomas are frequently difficult to resect from the side wall and thus present the possibility of unrecognized endometriosis being left on the broad ligament. Although some surgeons suture these areas, there appear to be fewer adhesions if suturing is not performed. The success rates have been excellent for these operations[18,73] (see Chap. 6).

Alternately, a portion of the roof of the endometrioma can be excised and the cavity then ablated with use of the laser in "touch" or "no touch" techniques. This method is similar to Semm's early techniques with the endotherm and should be expected to have a high rate of residual disease.[88] At the completion of the procedures, the pelvis should be copiously irrigated to remove as much char tissue as possible and to ensure that hemostasis has been attained.

Cul-de-sac nodularity may be noted in the rectovaginal septum at preoperative examination but not at laparoscopy. Therefore a rectovaginal examination is performed after excision in all situations where this nodularity was noted preoperatively.[18] When the nodularity is still present, the excision is continued through the laparoscope via a vaginal incision or at laparotomy. An alternate approach is to treat the nodularity with medical suppression or expectant management.

Postoperative adhesions following laser excisions have not been a major clinical problem. The results have been similar to Semm's findings following pelviscopic sur-

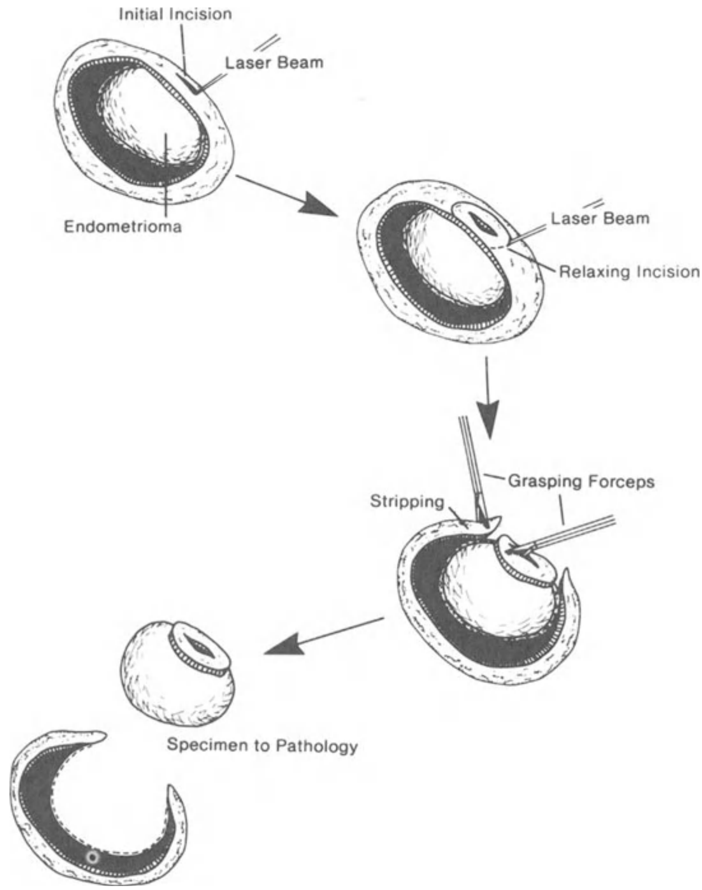

FIGURE 16-11. Initial opening incision is made into the endometrioma with a laser. After the endometrioma has been lavaged and examined, a relaxing incision is made through healthy ovary. The specimen and healthy ovary are then grasped and the specimen stripped out of the ovary and subsequently submitted for histologic examination. (From Martin DC, ed: Intra-abdominal Laser Surgery, 2nd ed. Resurge Press, Memphis, in preparation.)

gery.[88] However, investigation of postlaparoscopic adhesion development has not been as extensively studied as adhesion formation and re-formation after laparotomy.[89] These excisions leave minimal ischemic tissue and have caused few adhesions. This finding is compatible with previous laboratory and human findings.[90–96] Adhesions appear to be related more to ischemia caused by suturing than to necrotic tissue resulting from the use of laser, bipolar coagulation, or thermal coagulators. As an extreme, the massive destruction caused by bipolar and unipolar coagulation of the tubes results in few adhesions. This result has been noted in those patients who have been examined for possible tubal reversal. Ongoing study and correlation are needed to confirm this observation.

Accuracy and confirmation of endometriosis have been studied and reported.[18,39,40] Using laser excisional technique, an increasing number of patients have had tissue sent for study over the course of development of laser techniques (13% in 1982, and 100% in 1986). At the same time the percentage of confirmation in the laboratory has increased. Histologic confirmation occurred in 62% of the specimens in 1982 and 97% in 1986. Overall, the total result was confirmated in 8% of

TABLE 16-5. Accuracy of techniques

Year	No. of patients	Patients with specimens sent	Patients with positive specimens	Specimens positive (%)
1982	97	13 (13%)	8 (8%)	62
1983	91	34 (37%)	16 (19%)	50
1984	91	65 (71%)	59 (65%)	91
1985	97	88 (91%)	84 (87%)	95
1986	119	119 (100%)	116 (97%)	97

As the use of excisional techniques increased, the accuracy of these techniques also increased.[18,39,40]
From ref. 40, with permission of The Journal of Reproductive Medicine.

TABLE 16-6. Pregnancy rate related to presence of endometriosis

Condition	No. of patients pregnant, by stage of endometriosis		
	Mild	Moderate	Severe
Endometriosis as an isolated factor	145/199 (73%)	109/135 (66%)	24/40 (60%)
Endometriosis with other factors	133/284 (47%)	47/169 (28%)	9/24 (37%)

When analyzed by stage, there was a decreased pregnancy rate in patients with multiple factors.[18]
From ref. 18, with permission of Year Book Medical Publishers.

patients in 1982 and 97% in 1986 (Table 16-5).

Reports on fertility following laser surgery have been compatible with previous studies and have been remarkably reproducible.[18] (Tables 16-6 and 16-7) with both the CO_2 laser and the argon laser (Table 16-8).

TABLE 16-7. Pregnancy rates related to endometriosis and other factors

Study	Pregnancy rate in women with one or multiple factors	
	Isolated factor	Multiple factors
Feste[67,68]	42/60 (70%)	40/80 (50%)
Martin[35]	23/34 (68%)	32/81 (40%)
Nezhat & Growgey[72]	62/102 (61%)	—
Paulson & Asmar[74]	169/229 (74%)	56/203 (28%)
Total	296/425 (70%)	128/364 (36%)

Patients with endometriosis as an isolated factor had higher pregnancy rates than those with multiple factors ($p < 0.01$).

In addition, life table analysis has demonstrated that CO_2 laser laparoscopy produces results comparable with or better than laparotomy or medical suppression for mild, moderate, and severe endometriosis.[73] However, surgery for endometriosis is not the only answer when other factors are present[18,35,73,76] (Tables 16-9 and 16-10). (Chapter 17 further addresses endometriosis from both pelviscopic and laser resection perspectives and includes the American Fertility Society classification.)

Ectopic Pregnancies

Excisional and conservative techniques of managing tubal pregnancies have been reviewed in other chapters (see Chap. 5) and in other publications.[18,97] Linear salpingostomies have been performed with the CO_2 laser,[65,98–100] the argon laser,[101] and the KTP laser[11,78] (Fig. 16-12). These techniques are similar to those using coagulation and are

TABLE 16-8. Pregnancy rates after laser treatment

Study	Laser	Pregnancy rate, by length of infertility	
		0–2 years	3 or more years
Keye et al.[76]	Argon	5/8 (63%)	14/48 (29%)
Martin[35]	CO_2	30/44 (68%)	26/71 (37%)

Pregnancy rates decreased with increased length of infertility with both argon and CO_2 lasers.

based on the anticipation of finding an ectopic pregnancy in a high risk patient. When the CO_2 laser is used, button-type coagulation irrigators may be needed for precise coagulation of bleeding from the base of the ectopic site. Pitressin injection also helps decrease this bleeding.

The main worry when performing a conservative operation for an ectopic pregnancy is the chance of persistent viable trophoblastic tissue. Such tissue has been noted at both laparotomy and laparoscopy.[101–105] In addition, although salpingostomy has worked well with ampullary pregnancies, the efficacy of this procedure in isthmic pregnancies is less clear.[106] Futhermore, conservative operations can convert a stable situation into a hemorrhagic emergency.

TABLE 16-9. Pregnancy rates and years of infertility.

Years of infertility	No. of patients pregnant/total patients	
	Endometriosis only	With other factors
1–2	14/17 (82%)	16/27 (59%)
3–7	9/17 (53%)	16/41 (39%)
8–13	0 (0%)	1/13 (7%)

The pregnancy rate decreased with increasing years of infertility and with multiple factors ($p < 0.01$ comparing number of factors; $p < 0.01$ comparing years of infertility).
From Martin,[35] with permission of The Journal of Reproductive Medicine.

TABLE 16-10. Association of male factor with low pregnancy rates.

Study	Patients	Pregnancies
Keye et al.[76]	17	2 (12%)
Martin[35,73]	14	1 (7%)
Total	31	3 (10%)

These problems are thoroughly discussed in Chapter 5.

Adhesiolysis

The CO_2 laser is used at high power densities of 3,000–15,000 watts/cm^2 to incise adhesions.[21–23,28,64–68] Argon[76,107] and KTP[11,78,79] lasers have also been used. Backstops and barriers for limiting laser penetration can be useful. If the tissue is too wet, penetration of the CO_2 laser is limited and the water will boil on the surface. The lateral side-wall can be used with extreme care. The accuracy of the laser has been very useful in dissecting dense adhesions. Filmy adhesions can be treated as easily with coagulation and scissors.

Cuff Salpingostomy

Daniell[108] reported a 25% pregnancy rate in 22 patients and Mage et al.[30] a 30% rate in ten patients following laparoscopic cuff salpingostomy with the CO_2 laser. The laser was used to incise into the hydrosalpinx in radial and linear fashion. The cuff was then turned back with use of a low power density beam to coagulate the serosa. Similar procedures have been performed with the argon[107] and KTP[79] lasers, although numbers remain too small for appropriate analysis of pregnancy outcomes. Tulandi[109] has reviewed laparoscopic tubal surgery and noted that patients with hydrosalpinges should be considered for in-vitro fertilization. (The reader is referred to Chapter 10.)

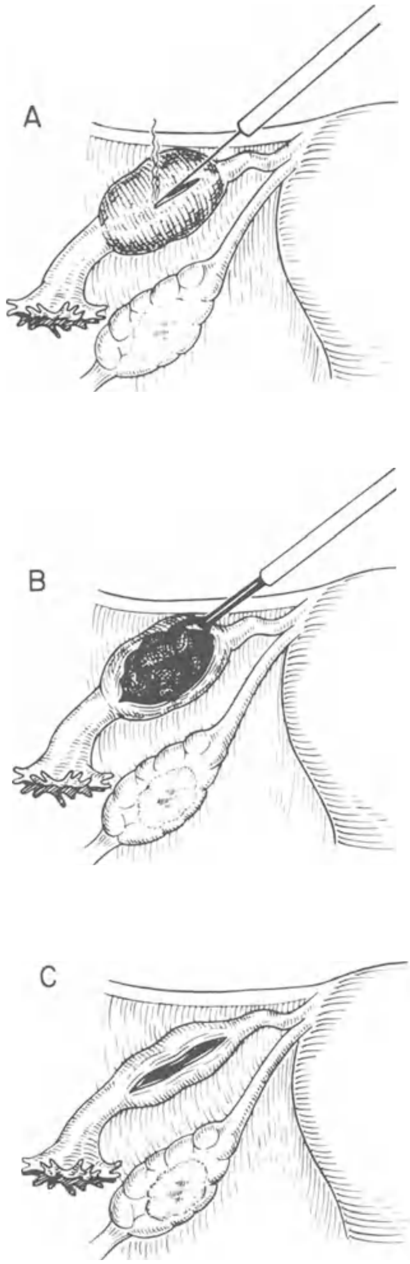

FIGURE 16-12. Linear salpingostomy for an ampullary ectopic pregnancy is performed with the use of the laser beam. (A) The laser is first used to make a linear salpingostomy. (B) It is followed by grasping and removing the products of conception. (C) The incision is allowed to heal without primary closure. (From Diamond and DeCherney.[97])

Doyle Procedure

Feste[28,67,68] and Daniell[64,65] have reported up to 70% relief from dysmenorrhea using the CO_2 laser to vaporize the uterosacral ligaments at the uterine insertion. This procedure is similar to that of Doyle,[110] reported in 1955. Lichten and Bombard[111] reported statistically significant pain relief at both 3- and 12-month follow-up in a prospective study. Lichten used the term laparoscopic uterine nerve ablation (LUNA). others have used the argon laser[107] and the KTP laser[11,78,79] for similar procedures (see Chap. 17).

Stein-Leventhal Syndrome

Aspiration of the multiple cysts in Stein-Leventhal syndrome has been shown to serve as a "pseudo" type resection.[112–116] It has been performed with the CO_2,[64,65,117] argon, and KTP[78,117] lasers. It is hoped that the adhesions that follow classical wedge resections[118] will not follow these procedures (see Chap. 6). Unipolar knives appear to be easier to use than coagulators, aspiration needles, or lasers.

Tubal Sterilization Reversal

Although tubal anastomoses have been performed laparoscopically with an endocoagulator,[119] electrosurgical technique (Reich H, unpublished data), and CO_2 laser,[69] there have been no ongoing pregnancies reported with these techniques although both miscarriage and tubal pregnancies have been reported. This procedure has been purported to be less expensive than microsurgical anastomosis. In contrast, microsurgical anastomoses have been performed as outpatient laparotomy procedures (Hunt RB, Martin DC, unpublished data). The cost of these approaches should be comparable.

Complications

Complications, as reported in the literature and discussed at meetings, have been uncommon and are essentially the same as complications reported with operative laparoscopy.[15–20,120] Complications that have occurred in more than 20,000 cases performed through 1988 include the following:

1. Hypothermia (92°C) due to lavage solutions
2. Dissecting emphysema
3. Loss of pusher sponge in the deep pelvis
4. Transient ileus
5. Hemorrhage from deep pelvic vessels
6. Partial amputation of a hydrosalpinx
7. Transection of a fallopian tube in adhesions
8. Transfusion
9. Laparotomy for bowel laser incision
10. Laparotomy for bowel laceration
11. Laparotomy for iliac vessel laceration
12. Colostomy for bowel laceration
13. Ureteral implantation for ureteral transection
14. Death due to cardiac arrest

In one author's experience (Martin DC, unpublished data), laparotomy was used only twice among 635 cases. During that time, an estimated 75–300 laparotomies were avoided using laparoscopic techniques. Both of the laparotomies were performed in patients with extensive adhesions. The first patient had bleeding from beneath a densely adherent ovary, and the second had endometriosis with puckering of the colon. Neither case was recognized until adhesiolysis had been performed. Laparotomy was performed in the second patient for definitive bowel surgery. Part of this technique is being prepared with alternate plans when clinical assessment indicates changes during the course of surgery.

Conclusions

Laser laparoscopy belongs in the larger body of experiences in operative laparoscopy. At present, the decision to use lasers, bipolar coagulators, thermal coagulators, sharp incision, and unipolar knives is based on the surgeon's and patient's interpretation of current data. Most of these data are preliminary. It is hoped that continued study will indicate the equipment that is most useful for a given situation.

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17 Endometriosis

JOSEPH S. SANFILIPPO

Endometriosis is a common cause of morbidity in the gynecologic patient, though rarely is it life-threatening. Endometriosis is well known as the presence and growth of stromal elements in aberrant sites. This tissue is usually identical to that found in the lining of the uterus. Clinically, the patient with endometriosis often presents with progressively painful pelvic discomfort in association with menstruation. Dysmenorrhea, dyspareunia, dyschezia, premenstrual staining, suprapubic pain with dysuria, and cyclic hematuria, as well as infertility, are frequent symptoms. The exact incidence of endometriosis is difficult to ascertain. However, it may account for up to 66% of female infertility.[1,2] Although primarily a disease in women of reproductive age, adolescent patients are not spared from this affliction. In fact, a diagnosis of endometriosis has been documented by laparoscopic biopsy in a 10-year-old![3] The incidence of endometriosis seems to increase with frequency of spontaneous first trimester abortions, hyperprolactinemia, or menstrual irregularity associated with anovulatory cycles.[4,5]

Clinical management of the condition varies according to the patient's age, desire for fertility, and presence or absence of associated reproductive tract anomaly. For patients with reproductive tract anomalies such as blind vaginal pouch, the progression of endometriosis has been completely reversed in some cases by the surgical creation of a "window" that mitigates the obstruction into the outflow tract and reduces suppression of menstrual efflux.[6] A relatively new avenue of exploration is the possible immunologic etiology of endometriosis.[7] Research in this area will, in all probability, result in new modalities of diagnosis and treatment. It is the objective of this chapter to provide an orderly approach to the etiology and diagnosis of endometriosis and to discuss alternatives to management, emphasizing the laparoscopic surgical alternatives available to the clinician.

Anatomic Findings

In most cases, endometriosis involves the ovary. Another area frequently affected is the cul-de-sac in which the endometriosis may be associated with bluish punctate hemorrhagic areas or petechiae. Cysts lying beneath the surface of ovarian epithelium may also be related to endometriosis in the form of endometriomas. Normally, the fallopian tubes remain patent; in general, the more advanced the lesion, the poorer is the prognosis and greater the histologic abnormality.[8] Rupture of an ovarian endometrioma often results in pain, dissemination of endometriosis, and chemical peritonitis, which may lead to the formation of adhesions.

On physical examination, endometriosis often presents with cul-de-sac tenderness and nodularity. An adnexal mass may also be present. Uterine retrodisplacement is not uncommon. Differential diagnosis must include adenomyosis as well as ovarian pathology, pelvic inflammatory disease, and gastrointestinal tract abnormality.

Wild and Wilson[9] have made a number of significant clinical observations regarding endometriosis: (1) it is a disease of women in their reproductive years; (2) the disease occurs after menarche; (3) it is common in women who have uninterrupted cyclical menstruation for periods of over 5 years; (4) it improves subjectively and objectively during pregnancy and artificially induced anovulation (danazol or oral contraceptives); (5) frequent pregnancies, if initiated early in menstrual life, prevent development of the disorder; (6) commonly, it is associated with female infertility; (7) a polygenic multifactorial mode of inheritance occurs in families; and (8) recurrence rates of 5–20% per year have been reported.[10]

TABLE 17-1. Proposed mechanisms for endometriosis-associated infertility

Peritoneal fluid
Direct toxic effects
Prostaglandins
Macrophages
Immune dysfunction
Ovarian dysfunction
Anovulation
Luteal phase inadequacy
LUFS
Abnormal LH surge
Prolactin excess
Spontaneous abortions
Hereditary factors

From Wilson E (ed): Endometriosis. New York, Alan R. Liss, 1987.

Immunology

The immunologic basis of endometriosis is a fascinating new area of research. It is possible that endometrial proteins in the peritoneal fluid induce an autoimmune response at the foci of the aberrant endometrium and release anti-endometrial antibodies into the circulatory system (serum).[11] Changes in local levels of immunoglobulins may affect sperm phagocytosis and systemic immune responses. Activation and alteration of the complement system may be associated with endometrial antibody activity.[11] Immunoglobulin G (IgG) binding in the endometrium has also been demonstrated by Mathur et al.[12] The associated autoimmune mechanism of endometriosis related infertility is outlined in Table 17-1.

Medical Therapy

The most common modes of medical treatment for endometriosis include danazol, oral contraceptive suppression, medroxyprogesterone acetate, and analogs of gonadotropin-releasing hormone (GnRH). Danazol is an isoxazole derivative of 17α-ethinyl testosterone. Its mechanism of action includes interaction and alteration of steroid hormone receptors as well as interaction and alteration of enzymes of the steroidogenic pathway. Danazol affects directly the endometrium, endometriotic tissue, ovariofolliculogenesis, liver proteins, and the immune system.[12,13] As a rule, danazol is administered in 800 mg daily dosages for a period of 3–6 months, usually the latter. Side effects that may be associated with danazol therapy include acne, hirsutism, deepening of the voice, decrease in breast size, weight gain from fluid retention, hypertension, alopecia, urticarial reactions, and transient "leg pains." Significant alterations in cholesterol metabolism have been reported in individuals undergoing long-term danazol therapy. For example, the induced decrease in high density lipoproteins (HDL) and increase in low density lipoproteins (LDL) can adversely effect the cardiovascular system.[14] Danazol therapy has been successful in alleviating dysmenorrhea in 90% of patients receiving treatment; pregnancy rates for patients after danazol therapy have been reported to be about 37%.[15,16]

Prior to any decision on treatment, review of the American Fertility Society's Revised Classification for staging of endometriosis is recommended (Table 17-2). In a study of 20 patients, Siebel and colleagues[17] reported minimal endometriosis to be associated with a 30% pregnancy rate in patients who received danazol therapy as compared with a 50% pregnancy rate in patients for whom no treatment was prescribed. In addressing stages I and II endometriosis, Barbieri and colleagues[15] noted a 46% pregnancy rate in patients who received no treatment.

Oral Contraceptives and Steroids

Estrogen-progestin preparations, usually in dosages of 35 μg, produce an anovulatory, acyclic hormonal environment, labeled traditionally as a "pseudopregnancy." Patients receiving this treatment have shown 30% symptomatic improvement and 18% objective improvement.[18] When compared with danazol therapy, the estrogen preparations have proved to be less efficacious.[18] Another medical therapy is the use of methyltestosterone (Android-5 Buccal, Brown Pharmaceutical Company, Los Angeles, CA), 5 mg linquets administered bucally daily. Although this treatment does not produce anovulation, it does provide relief from symptoms of endometriosis. However, fertility rates are significantly lower with this therapy than with danazol.[19] "Progestin only" regimens, such as medroxyprogesterone acetate, norethindrone acetate, and lynestrenol, have been used as single agents for the treatment of endometriosis.[20] A hypoestrogenic-acyclic hormonal environment with anovulation results. Depo preparations of medroxyprogesterone acetate have also been used in dosages based on surface area; they are administered every 1–3 months. Depo medication is not a "first line" treatment, as it can produce prolonged amenorrhea at termination of therapy.

Gonadotropin-Releasing Hormone Agonist

Administration of GnRH agonists (GnRHa) initially produces an increase in serum gonadotropins (FSH and LH), then a drastic fall. This rise and fall may be secondary to down-regulation of pituitary GnRH receptors, the result of which is a hypogonadotropic effect.[21,22] The GnRH agonist has been used to treat endometriosis as well as other gynecologic abnormalities such as chronic anovulation syndrome, precocious puberty, endometrial hyperplasia, premenstrual syndrome, and uterine leiomyomas. The most commonly used agonist at present is leuprolide acetate (Lupron®, TAP, Abbott Pharmaceuticals, North Chicago, IL) which is available for daily injection in addition to depo preparations. Two additional agonists have been used in scientific protocols: nafarelin acetate (Synarel®, Syntex Laboratories, Palo Alto, CA) and buserelin acetate (Suprefact®, Hoechst-Roussel Pharmaceuticals, Somerville, NJ). In general, these agonists are administered subcutaneously in 100 μg dosages. Ultimately, the resulting serum estradiol and androgen levels reach the "castrate level" within 10 weeks following initiation of therapy.[22]

Buserelin, on the other hand, is administered at 300 μg subcutaneous and intranasal doses. It is initially prescribed in twice daily dosages for a period of 5 days, followed by 400 μg intranasal administration three times daily. Side effects of GnRH therapy are related primarily to hypoestrogenemia and include the menopausal symptoms of insomnia, vaginal dryness, mild transient depression, decreased libido, and occasional breast tenderness. Reports of increased leukocytosis have also been noted.[23] Continuing experimental protocols are underway in an effort to determine the efficacy of GnRH agonists in the treatment of endometriosis.

TABLE 17-2

THE AMERICAN FERTILITY SOCIETY REVISED CLASSIFICATION OF ENDOMETRIOSIS

Patient's Name ____________________ Date ____________

Stage I (Minimal) - 1-5
Stage II (Mild) - 6-15
Stage III (Moderate) - 16-40
Stage IV (Severe) - >40
Total ________

Laparoscopy ________ Laparotomy ________ Photography ________
Recommended Treatment ____________________

Prognosis ____________

	ENDOMETRIOSIS	< 1cm	1-3cm	> 3cm
PERITONEUM	Superficial	1	2	4
	Deep	2	4	6
OVARY	R Superficial	1	2	4
	Deep	4	16	20
	L Superficial	1	2	4
	Deep	4	16	20

POSTERIOR CULDESAC OBLITERATION	Partial	Complete
	4	40

	ADHESIONS	< 1/3 Enclosure	1/3-2/3 Enclosure	> 2/3 Enclosure
OVARY	R Filmy	1	2	4
	Dense	4	8	16
	L Filmy	1	2	4
	Dense	4	8	16
TUBE	R Filmy	1	2	4
	Dense	4*	8*	16
	L Filmy	1	2	4
	Dense	4*	8*	16

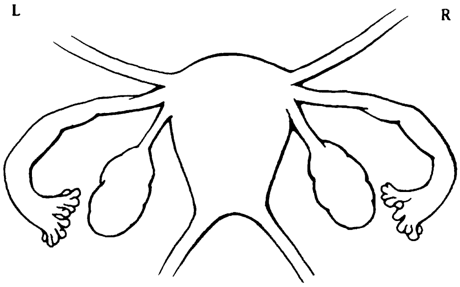
*If the fimbriated end of the fallopian tube is completely enclosed, change the point assignment to 16.

Additional Endometriosis: ____________________

Associated Pathology: ____________________

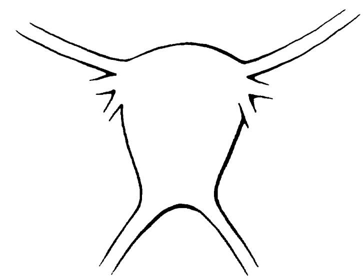
To Be Used with Normal Tubes and Ovaries

L R



To Be Used with Abnormal Tubes and/or Ovaries

L R



Revised American Fertility Society Classification of Endometriosis, 1985. Fertil Steril 43:351, 1985. Reproduced with permission of the publisher. The American Fertility Society.

Gestrinone (R 2323)

Gestrinone is a 19-nortestosterone derivative that has progestational agonist and antagonist properties. R 2323 binds to both estrogen and progesterone receptors as well as to sex hormone binding globulin (SHBG).[24] It produces hypothalamic pituitary suppression with a subsequent fall in circulating estrogen levels and a decreased pituitary response to GnRH stimulation. As treatment for endometriosis, it is administered orally in 2.5 mg dosages two or three times per week. Amenorrhea results in 85%–90% of patients receiving therapy along with a rapid decline in abdominal pain and dysmenorrhea.[24] Side effects of the drug include headaches, breakthrough bleeding, decrease in breast size, and transient leg pain with associated fluid retention and edema.

Interleukin

Another consideration in the treatment of endometriosis is the role of interleukin-1.[25] Ongoing research will one day provide further information on the role of this polypeptide in the immune response and endometriosis.

Surgical Approach to Treatment of Endometriosis

Surgical evaluation is initiated by diagnostic laparoscopy, which may lead to intraoperative treatment, usually laser vaporization, excision, or fulguration of foci of endometriosis (Figs. 17-1 and 17-2). Management, however, is often dictated by a patient's desire for fertility. Exploratory laparotomy with "conservative procedure for endometriosis" is indicated if a laparoscopic approach is not feasible. Bowel involvement of endometriosis may necessitate laparotomy.

Laser therapy has opened new vistas to the management of endometriosis. The types of laser most often used in this surgery include carbon dioxide (CO_2), argon, neodymium-YAG (Nd:YAG), and potassium titanyl phosphate (KTP) twin crystal, as well as newly developed units such as the free electron lasers.

CO_2 Laser

Use of the CO_2 laser in surgical procedures for endometriosis has a number of advantages, one of which is greater precision in eliminating foci of endometriosis. Also, it provides faster healing and less scar formation than do the more conventional laparotomy excision techniques. As presented in Chapter 15, L-A-S-E-R is an acronym for "light amplication by the stimulated emission of radiation." The radiation is collimated, coherent, and monochromatic. Tissue reaction and the thorough description of the physics and mechanics of lasers are discussed in Chapters 14–16.

Laparoscope laser systems are available from a number of manufacturers. The equipment is comprised of an operating channel, usually 5 mm, in a laparoscope with a 10.0–12.7 mm external diameter. The laser is attached via an articulating arm and coupler to which a joystick is attached. In many cases, a 300–mm zinc arsenide focusing lens is used to obtain a beam focus 2 cm distal to the tip of the operating channel. On the average, the spot size is 0.5 mm in diameter. A helium neon (HeNe) beam is employed to align the CO_2 laser beam, which is not visible to the naked eye. A power density of approximately 3000–5000 watts/cm^3 is used for gynecologic procedures (Table 17-3). Calculation of power is discussed in Chapter 14.

The mechanics of the CO_2 laser delivery system through a laparoscope is as follows. When the foot pedal is depressed, the shutter opens and the laser beam is transmitted through a coupler-joystick via the CO_2 channel. After appropriate alignment of the CO_2 HeNe beam the laser is ready for use (also see Chap. 16).

TABLE 17-3. Power and spot size used for gynecologic procedures

Procedure	Power (watts)	Spot size (mm diameter)	Exposure time (sec-continuous)
Implants	2–5	0.4–2.0	0.1
Lysis of adhesions	5–15	0.4–2.0	0.1
Ovarian cystectomy	20–30	0.4–2.0	0.1

Operative Techniques

With the CO_2 laser it is possible to perform adhesiolysis as well as vaporization of endometriosis and resection of endometriomas. A double puncture technique is usually necessary to permit adequate evaluation of the pelvic organs. Other puncture sites are sometimes required for insertion of instruments such as backstops, rhodium mirrors, and the like. The area and amount of vaporization can be more easily regulated with the CO_2 laser because the operator has control of the impact zone and direction of the laser beam. The CO_2 laser wound is characterized by a zone of vaporization devoid of cellular material from the "boiling" of tissue, which results in a plume of cellular debris. The plume should be evacuated during the procedure. An area of thermal necrosis contains irreversibly damaged tissue and sealed vascular channels. There is also an area of injury in which cells may regenerate. Adjustment of power wattage, spot size, and method of administration (continuous or superpulse) all affect the amount of tissue destruction as previously described.

Other advantages of the CO_2 laser system include (1) a bloodless field, (2) depth of tissue penetration (0.1 mm), (3) residual zone of 100–600 μm, (4) the zone of coagulation producing hemostasis without leaving excessive necrotic tissue, (5) boiling of tissue to 100°C, and (6) capacity of the pelvis to be filled with fluid (normal saline), which is deemed necessary, according to safety standards, for the prevention of beam penetration.[26]

CO_2 laser therapy is not without its drawbacks. Occasionally, lens fogging can result in decreased transmission. Visibility of the helium-neon (HeNe) beam, as well as passage of the laser beam through intraperitoneal carbon dioxide, can cause reduction of the laser power density. Complications of bleeding, extravasation of fluid, and punc-

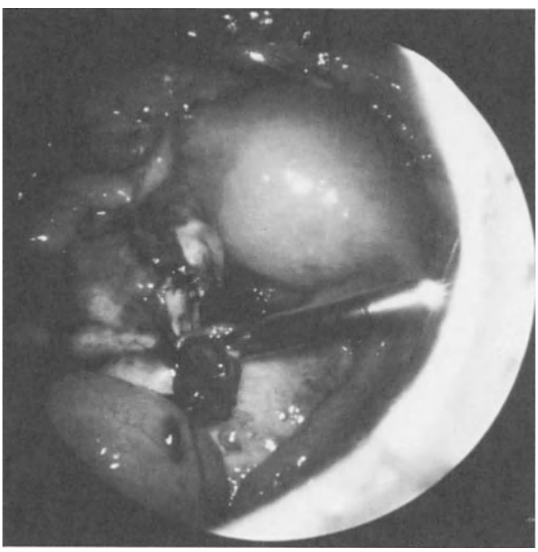


FIGURE 17-1. Ovarian involvement with endometrioma. Cyst resection.

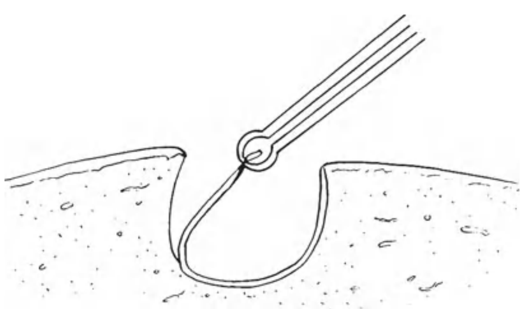


FIGURE 17-2. Resection of cyst (endometrioma) wall.

ture of the uterus and bladder have been reported.[27] Removal of the laser plume requires a separate puncture channel; otherwise a moist plume clouds the lens.[27,28] A backstop is cumbersome to use in some instances, depending on the pelvic findings. As stated in Chapter 3, instillation of high-molecular-weight dextran (Hyskon; Pharmacia, Piscataway, NJ) or Ringer's lactate at the completion of the surgical procedure aids in the prevention of postoperative adhesions.

Laparoscopic Surgical Techniques

Advanced laparoscopic surgical techniques are described in preceding chapters. It is appropriate to state that techniques of lysis of adhesions, use of endoloops, and laparoscopic suturing are applicable to laparoscopic treatment of endometriosis. Figures 17-1 and 17-2 illustrate the pelviscopic techniques used in resecting endometriomas.

Videolaseroscopy makes it possible for the surgeon to avoid back strain and of course provides a permanent video recording of each case (see Chap. 11). Pregnancy rates after treatment with the CO_2 laser are presented in Tables 17-4 and 17-5.

CO_2 Laser Delivery Through an Operating Microscope

Similar principles of excision, ablation, and vaporization of endometriosis apply in the delivery of the CO_2 laser through an operating microscope. A micromanipulator is often used to align the beam and in this way affect the delivery mechanism. It is possible to lyse adhesions through the hand-held CO_2 laser delivery system.

A continuous mode of laser delivery is usually necessary for the cul-de-sac area in order to completely eliminate the foci of endometriosis. However, a lower power density of ≤ 1000 watts/cm^3 with a pulsatile mode of approximately 1/120 second is sufficient for areas involving the bladder, peritoneum, lateral pelvic side wall, fallopian tube, and serosa of the colon.

Adjuncts to the CO_2 Laser Delivery System

Reflective silver surface mirrors as well as molybdenum or rhodium mirrors are often useful for laparoscopic procedures and laparotomy. Rhodium is especially useful as it has a melting point of 2000°C. The use of reflective mirrors permits access to ovarian fossa, uterine ligaments, and other inaccessible areas. In general, the surgical instruments should be retracting rods of silicon dioxide, which allow resistance to laser penetration. However, because these rods are prone to "fatigue" the instruments should be carefully inspected before each usage. Teflon-coated rods and annealed Pyrex glass should never be used with laser systems.

Argon Laser

Photocoagulation of peritoneal implants of endometriosis with the argon laser has been reported by Keye and Dixon.[34] The argon laser, delivered by means of a 600 μm flexible (steerable) quartz fiber light cable through the operating channel of the laparoscope, makes possible the selective absorption of the hemoglobin-filled structures. Advantages of the argon laser include (1) no plume, (2) foci of endometriosis photocoagulated rather than vaporized, (3) power setting of only 2 watts, (4) no resulting cavity defect, and (5) a delivery system easily placed through the operating channel of most laparoscopes.[34] However, the argon laser can use up to 15 watts of power with a 0.4 mm flexible fiber.

A number of disadvantages have been noted with the argon laser. Resection of adhesions is not as rapid as with the CO_2 laser. Also, there is increased lateral thermal ef-

TABLE 17-4. Pregnancy rates after treatment with CO_2 laser

Authors	Stage of endometriosis	No. of patients	Pregnancy rate (%)
Bellina et al.[29]	I–III	44	55
	IV	40	49
Chong & Baggish[30]	Severe	44	61
Kelley & Roberts[31]	I	3	67
	II	7	43
Feste[27]	Mild	22	73
	Moderate	4	75
	Severe	3	66
Martin[26]	—	52	48
Nezhat et al.[32]	I	24	75
	II	51	63
	III	19	42
	IV	8	50

fect when compared with that of the CO_2 laser.[34,35] In a study by Sharp et al.,[35] 50 patients with mild to moderate degrees of endometriosis were evaluated. Pregnancy rates following treatment of endometriosis with the argon laser were reported to be 68%.

Neodymium:YAG Laser

The neodymium:YAG (Nd:YAG) laser is unique in that it has an artificial sapphire tip. Lomano[36] conducted a prospective study on the use of the Nd:YAG laser for treatment of endometriosis with 24 patients who presented with clinical findings. All of the patients were placed on postoperative danazol therapy at 800 mg daily dosages for 3–9 months. At the time of surgery, the Nd:YAG laser, set at 20 watts, was used at intermittent 1–3-second exposures. The results of this study showed 100% improvement in dysmenorrhea for mild endometriosis within 6 weeks of treatment. Continuation of coagulation is recommended until an area 1 mm beyond the lesion border is blanched. Advantages of this technique include the optical fiber delivery system that can be used through the operating channel of most laparoscopes.

TABLE 17-5. Danazol vs. CO_2 laser

Treatment[a]	No. of patients	Pregnancy rate (%)
Danazol alone	49	44.8
Laser + postop danazol	32	65.5

[a] Danazol dosage = 200 mg tid × 6 months.
From ref. 33, with permission.

Potassium Titanyl Phosphate Laser

Daniell and colleagues[37] have conducted a study on the use of the potassium titanyl phosphate (KTP) laser for the treatment of endometriosis in ten patients presenting with dysmenorrhea. With this laser system, a flexible fiberoptic delivery apparatus produces surface vaporization of endometriosis with penetration of ≤ 2 mm.[37] The laser is a green beam, μ = 532 nm, with a 12 watt energy thrust. The delivery system has a 600 μm core flexible quartz optical fiber and requires a 3 mm laparoscopic operating channel. One of the disadvantages of this system is that there is greater coagulation than with the CO_2 laser. However, radiation dosages can be adjusted in order to obtain the desired ratio of cutting, vaporization, and coagulation. There is a radiation dosage of 532 nm with the KTP laser, as mentioned above, compared with 10,600 nm for the CO_2 laser.[37]

Free Electron Laser

The free electron laser (FEL) is a high energy electron beam that passes through a periodically alternating static transverse magnetic field called a "wiggler" or "undulator."[38] The "wiggler" is a series of magnets lined up in a manner that brings about alternating polarity. The resulting magnetic field forces electrons in the beam to oscillate in a transverse direction and to emit a laser beam in a forward direction. The FEL laser uses power of 10 kW to 1 mW. With a wavelength (μ) of 50 nm to 10 million nm, a pulse length of 10^{-12} second to infinity can be selected. The efficiency of the FEL laser is 10–20%. The importance of its role in the treatment of endometriosis is being evaluated in ongoing research.

Laser Uterosacral Nerve Ablation

One treatment for dysmenorrhea has been to resect a segment of the uterosacral ligament. It results in ablation of a comparable portion of the uterosacral nerve.[39] Of 21 patients with primary dysmenorrhea who were treated by laser neurectomy, 81% showed symptomatic improvement. The procedure was originally described by Doyle and Des Rosiers,[40] who advocated excision of the uterosacral ligaments adjacent to the cervix. The underlying concept of this procedure is the destruction of a significant number of sensory fibers to the cervix and lower uterine segment. Laser uterosacral nerve ablation (LUNA) involves resection of a 1.0–1.5 cm diameter segment of the uterosacral nerve at its apex, with a 1 cm depth of penetration.[40] Results of laser laparoscopy for treatment of dysmenorrhea and dyspareunia in association with endometriosis are presented in Table 17-6.

TABLE 17-6. Laser resection of uterosacral ligament for dysmenorrhea and dyspareunia in patients with endometriosis

	No. of patients, by stage			
Condition	Total	I–II	III	IV
Dysmenorrhea	146	41	19	18
Dyspareunia	109	35	13	10

From Davis.[28] Abridged with permission from The American College of Obstetricians and Gynecologists. (Obstetrics and Gynecology 1986; 68:422–425.)

Laparoscopic Electrocauterization of Endometriosis

Laparoscopic electrocauterization of endometriosis has resulted in "satisfactory" pregnancy rates. In one study of 66 patients with mild to moderate endometriosis, treatment with unipolar cauterization and danazol resulted in pregnancy rates of 67%.[41] However, cauterization should be approached with caution—perhaps even avoided—in areas over the bowel, bladder, ureter, and vascular segments of the broad ligament.

Conservative Procedure for Endometriosis

An inadequate knowledge of pelviscopic surgical techniques or lack of expertise in the use of laparoscopic lasers may lead the surgeon to elect to perform a conservative procedure for endometriosis such as laparotomy. There are a number of guidelines for proceeding with exploratory laparotomy, among which are (1) fibrosis in the rectovaginal septum, (2) inadequate visualization and mobilization of pelvic organs at laparoscopy, (3) necessity for ureteral and vascular dissection, (4) dense fibrotic adhesions in the sigmoid colon obliterating the cul-de-sac, and (5) bowel involvement with distortion of serosal surfaces.[26]

At the time the abdomen is opened, the upper regions should be routinely explored. Omental and bowel adhesions are lysed. The bowel is packed atraumatically with avoidance of internal genitalia abrasion. Gentle tissue handling is mandatory. Continued moistening of pelvic organs with lactated Ringer's solution is necessary in order to decrease adhesion formation. Endometriosis around the ovaries is treated by cauterization or laser vaporization when the involvement is superficial.

Deeper endometriomas require resection with excision of the capsule. Preservation of blood supply with complete removal of endometriosis and good reapproximation of excised segments of ovary, including the cortex, should be the goal of every surgeon performing a cystectomy. Unilateral involvement of endometriosis would necessitate resection of one fallopian tube and ovary. Intraoperative hydrotubation is easily accomplished with insertion of a pediatric Foley catheter (size 8 or 10, Bard, Indianapolis, IN) into the cervical canal and uterine cavity prior to initiation of surgery. A 3 ml balloon is best inflated with 2 ml of fluid. Reperitonealization of denuded surfaces, uterosacral ligament resection, and uterine suspension are helpful in preventing recurrence of pelvic adhesions. If laparotomy is performed, uterine suspension, approximation of uterosacral ligaments, and consideration for presacral neurectomy are in order. Again, general principles—in this case effective hemostasis, careful tissue handling, and use of 32% dextran 70 (Hyskon; Pharmacia, Piscataway, NJ) or Ringer's lactate left in the abdomen intraoperatively—appear to reduce adhesions[42] (see Chap. 3).

Occult appendiceal endometriosis occurs in 3% of women with pelvic endometriosis.[43] Bowel involvement of endometriosis occurs in 15% of patients with endometriosis and is frequently seen in the distal ileum.[43–45] Segmental resection and reanastomosis are necessary.[43–45] Definitive conclusions regarding follow-up laparoscopy ("second look" laparoscopy) after a conservative procedure for endometriosis remain to be established.[46,47] However, Pittaway and colleagues[48] reviewed the usefulness of short-interval follow-up laparoscopy in 16 women undergoing resection of endometriomas. Periovarian adhesions were noted in all patients. Six of the women conceived. The investigators concluded that follow-up laparoscopy 4–6 weeks after major surgery offers an opportunity for reassessment of the pelvis, lysis of adhesions, and an improved postoperative prognosis.

The algorithm of Wheeler and Malinak[49] describes treatment options for patients with endometriosis (Table 17-7). In large part, the choice depends on a woman's childbearing desires. Conservative surgery in the form of laparotomy is indicated for stages I and II endometriosis (AFS classification) only if medical or laparoscopic surgical treatment fails to relieve pelvic pain or if there is recurrence of endometriosis in a persistently infertile patient.

Results with Conservative Procedure

Following conservative procedure for endometriosis, pregnancy rates ranging from 13% to 94% have been reported.[50,51] Olive's literature review of 1635 patients is summarized in Table 17-8, noting percentages as follows: pregnancy rates of 62% for mild endometriosis, 52% for moderate disease, and 40% for severe endometriosis, yielding an average rate of 54%.[51] The role of pre- and postoperative danazol therapy has been addressed by many authors.[49,50]

Definitive Surgery and Hormone Replacement

Treatment in the form of hysterectomy with bilateral salpingo-oophorectomy (BSO) and hormonal replacement therapy may be necessary, especially for women past their childbearing years. Studies of estrogen re-

TABLE 17-7. Endometriosis treatment algorithm

	DESIRES CHILDBEARING		CHILDBEARING COMPLETE
CHIEF COMPLAINT	INFERTILITY	PELVIC PAIN	PELVIC PAIN
STAGES I & II	1 EXPECTANT Tx 2 LAPAROSCOPIC Tx 2 MEDICAL Tx 3 CSEL ± PSN 3 IVF/ET	1 LAPAROSCOPIC Tx 2 MEDICAL Tx 3 CSEL + PSN	1 LAPAROSCOPIC Tx 2 MEDICAL Tx 3 TAH ± BSO 3 CSEL + PSN
STAGE III	1 LAPAROSCOPIC Tx 1 CSEL ± PSN 2 MEDICAL Tx 3 IVF/ET	1 LAPAROSCOPIC Tx 2 CSEL + PSN 3 MEDICAL Tx	1 LAPAROSCOPIC Tx 2 MEDICAL Tx 3 TAH ± BSO 3 CSEL + PSN
STAGE IV	1 CSEL - PERIOPERATIVE MEDICAL Tx 2 CSEL ALONE 3 LAPAROSCOPIC Tx - POSTOPERATIVE MEDICAL Tx 4 IVF/ET	1 CSEL + PSN + PERIOPERATIVE MEDICAL Tx 2 MEDICAL Tx 3 LAPAROSCOPIC Tx + MEDICAL Tx	1 TAH ± BSO 1 CSEL + PSN + MEDICAL Tx 2 LAPAROSCOPIC Tx + MEDICAL Tx

CSEL — conservative surgery for endometriosis at laparotomy
PSN — presacral neurectomy
TAH — total abdominal hysterectomy
BSO — bilateral salpingo-oophorectomy
IVF/ET — in vitro fertilization/embryo transfer
" ± " — indicates adjunctive treatment option based on individual patient findings

Treatment options for patients with endometriosis. First, determine the patient's interest in childbearing and her major complaint. The therapeutic options are listed for each AFS classification by order of preference; two treatments at the same rank have similar levels of preference. Reprinted with permission of Alan R. Liss, Inc., New York, NY, *Endometriosis*, E. Wilson (Editor), 1987.

TABLE 17-8. Pregnancy rates with conservative procedure for endometriosis

Stage of endometriosis	No. patients	Pregnancy rate (%)
Mild	278	62
Moderate	363	52
Severe	382	40
Overall	1023	50

Adapted from ref. 51, with permission.

placement therapy following BSO for endometriosis tend to support the theory that the advantages outweigh the risk of reactivation of remaining foci of active endometriosis when physiologic doses are prescribed.[52] The risk of recurrent endometriosis postsurgery is 3% at 5 years and seems to be little affected by ovarian preservation.[52]

Is Conservative Procedure for Endometriosis Slowly Being Replaced by Pelviscopic Surgery and Laser Laparoscopy?

There is evidence that the more conservative laparoscopic approach is often used to lessen the potential for adhesion formation following laparotomy. Frangeheim[53] noted that large endometriomas could be punctured through the laparoscope and the contents aspirated. Sixty percent of the masses did not refill; 40% required surgical removal. A complete resolution of an endometrial cyst by means of "puncturing" is related to the histologic observation that no vestige of endometriosis tissue is observed in a number of typical "chocolate" cysts. The recurrent hemorrhage and pressure atrophy cause obliteration of the microscopic architecture.[54] Nezhat et al.[32] have addressed laparoscopic excision of endometriomas up to 7 cm in diameter; DeCherney[55] has stated that "the obituary of laparotomy for pelvic reconstructive surgery has been written; it is only its publication that remains. Reconstructive surgery with the use of the endoscope will revolutionize gynecologic surgery."

Treatment of Endometriosis in the Adolescent

The primary focus of treatment for the adolescent is relief from pelvic pain, as in most cases the patient has no immediate interest in fertility. If a young patient fails to respond to nonsteroidal anti-inflammatory drugs (NSAIDs) and/or ovulation suppression, she should be laparoscoped. Preoperative discussion must outline plans for surgical intervention, including laser or cauterization techniques for obliteration of endometriosis. When fulguration of implants and lysis of adhesions are performed during laparoscopy, there is more relief from symptoms than when laparoscopy is performed for diagnosis alone.[56] On rare occasions, conservative surgery in the form of laparotomy is necessary during the same operative setting.

When managing endometriosis in an adolescent, it is of the utmost importance to rule out congenital anomalies in the reproductive tract that may obstruct segments of the outflow channel.[6] The presence of such an anomaly can often produce endometriosis with resulting pain; however, as noted previously the condition seems to be reversible with construction of a good outflow tract.[56] Medical therapies are similar to those prescribed for adults (see section on Medical Treatment).

Role of In-Vitro Fertilization in the Treatment of Endometriosis

The Norfolk experience with 62 infertility patients refractory to standard methods of treatment demonstrated a pregnancy rate per cycle of 48.7% with minimal or mild endometriosis.[57] In categories of moderate and severe endometriosis, the pregnancy rate was 15.9% per cycle.[57] Clinicians should keep in mind the option of in-vitro fertilization for endometriosis "refractory" to more conservative medical and surgical methods of treatment.

Management of Recurrent Endometriosis

Efforts should be made to excise all endometriosis during the initial surgical procedure. If it is not possible, postoperative medical therapy should be considered. Aggressive conservative surgery (cytoreduction) also seems to be helpful.[58]

Some of the pitfalls of initial treatment are failure to completely resect cul-de-sac or rectosigmoid implants and residual ovarian disease secondary to failure to adequately evaluate ovarian involvement for the presence of endometriomas.

Overall, it is difficult to give an exact estimate for rate of endometriosis recurrence. However, percentages ranging from 2% to 47% have been reported.[59,60] With respect to length of time following conservative surgical treatment, recurrence rates of 13.5% at 3 years and 40% at 5 years have been reported.[61] In part, the reported incidence of recurrence is a reflection of duration of follow-up and diligence of initial surgery. Puleo and Hammond[62] reported a recurrence rate of 38% for patients receiving danazol therapy. As stated above, recurrence following radical surgery is less—3% for total abdominal hysterectomy and BSO.[52] Recurrence rates for bowel involvement, in large part, reflect the aggressiveness of the original surgical excision.[62–64]

Summary

As techniques of gynecologic endoscopy continue to evolve, we find ever expanding roles for these specialized procedures. Treatment of endometriosis is one area amenable to laparoscopic treatment. As gynecologists become more proficient in endoscopic skills, the "traditional" approach of merely determining the presence of endometriosis by means of diagnostic laparoscopy is rapidly being replaced by immediate surgical correction of the problem. It is resulting in fewer indications for postoperative medical therapy and exploratory laparotomy.

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18 Diagnostic and Operative Hysteroscopy

JAMIL A. FAYEZ

Hysteroscopy was first performed more than 100 years ago,[1] but the procedure was practiced by few physicians until recently. Modern hysteroscopy began approximately 20 years ago when Lindeman[2] developed a method for distending the uterus with CO_2 and Edstrom and Fernstorm[3] devised a distention method using high-viscosity liquid dextran 70. The main reason behind the revived interest in hysteroscopy was the desire to find a simple, effective method of transcervical sterilization.

Hysteroscopy has developed into a highly sophisticated, effective technique with increasing applicability. It is no longer a procedure looking for an indication; its diagnostic and operative value has been well established. With the development of fiberoptics as a reliable high intensity light source without danger of thermal injury, and with improved methods of distending the uterus, hysteroscopy has been used in diverse applications in both diagnostic and therapeutic procedures. The author firmly believes that the time will come when no gynecologist can be considered thoroughly trained without having mastered this endoscopic technique.

Instruments

Hysteroscopes are manufactured by many companies. Those made by Wolf (R. Wolf Co., Rosemont, IL) or Storz (Karl Storz Endoscopy America, Culver City, CA) are more popular in the United States. Three types of hysteroscope are currently in common use: panoramic, microcolpohysteroscope, and contact.

The panoramic hysteroscope is a modified version of the cystoscope with a telescope 4–6 mm in diameter and a fore-oblique lens system. An external stainless steel sheath approximately 7 mm in diameter is used for introduction of the telescope. This sheath is equipped with stopcock-controlled channels for introduction of the distending medium. Storz provides an obturator for easy introduction of the sheath. Ancillary instruments introduced through a separate operating channel in the telescope, or in the sheath for intrauterine manipulation and operative procedures, include different types of forceps, scissors, probes, suction cannulas, and curettes. These instruments can be flexible, semirigid, or rigid. The latter are easier to handle and more efficient in operative hysteroscopy. The author believes that there is no place for flexible instruments in operative hysteroscopy.

The Hamou microcolpohysteroscope (Karl Storz Endoscopy America) is a composite instrument that provides for observation in both the panoramic and contact modes. The Hamou microcolpohysteroscope is equipped with a lens system that permits observation with magnification of 1–150X. The telescope is 4 mm in diameter, and a 5.2-mm sheath allows insufflation with CO_2, which is the only distending medium used with this type of hysteroscope. Although any magnification can be used for contact work, 1× and 20× are usually employed for panoramic and close views, respectively. Gynecologic oncologists can evaluate an abnormal Papanicolaou smear or determine the length of a cone biopsy, taking advantage of the specialized magnification that is available. Because of its small external diameter, it can be used in the office for diagnostic purposes.

The contact hysteroscope manufactured by the MTO Company in Paris and distributed in the United States by Advanced Biomedical Instruments (Waburn, MA) has at its proximal end an ingenious light trap that collects ambient room light. Therefore, external light is reflected into the uterine cavity through the hysteroscope to provide intrauterine visualization without expansion of the uterine cavity. No external light source is needed unless photography is to be undertaken. Contact hysteroscopy is performed with the objective lens of the telescope in contact with the structure under observation. Lack of a panoramic view of the intrauterine cavity necessitates careful interpretation of findings and curtails operative hysteroscopy. The author believes that contact hysteroscopy is much less productive than panoramic hysteroscopy and does not recommend its use. However, some hysteroscopists use the contact hysteroscope to visualize the interior of the pregnant or postpartum uterus and in the staging of endometrial carcinoma.[4]

Distention Media

The uterine cavity is a potential space rather than a real one. Its distention facilitates diagnosis and allows the performance of operative procedures. The distention media currently in use are high-molecular-weight dextran, dextrose 5% in water, and CO_2 gas insufflation.

High-Molecular-Weight Dextran (Hyskon)

As discussed in Chapter 3, Hyskon (Pharmacia Laboratories, Piscataway, NJ) is a dextran with an average molecular weight of 70,000 daltons made of 32% dextran 70 in 10% dextrose. It is an optically clear fluid with high viscosity and a high refractive index. Because of this refractive index, it does not distort images or reduce the field of vision. It is electrolyte-free, biodegradable, and nontoxic. Because Hyskon is nonmiscible with blood, it is particularly valuable in operative hysteroscopy. In addition, it is nonconductive, which means electrocautery can be performed hysteroscopically.

Reported complications include adult respiratory distress syndrome and coagulopathy, which may be lethal. In addition, anaphylaxis manifested by hypotension can occur, as Hyskon is an antigenic polysaccharide. The only practical disadvantage of using Hyskon is its sticky property, making it adhere to instruments as it dries. Unless the instruments are immediately immersed in warm water and thoroughly washed after each use, the stopcocks will jam and the instruments will not function properly during subsequent use. The author believes that Hyskon is superior to other media if intrauterine surgery is contemplated.

Dextrose 5% in Water

Dextrose 5% in water (D_5W) is readily available, simple to use, and does not pose any major risk. Instillation of D_5W for uterine distention is achieved by connecting a plastic bag containing 500 ml or more of the medium to one inflow channel of the sheath. The bag is wrapped with a blood pressure cuff inflated to 80–120 mm Hg. This system allows the fluid to run freely to the uterine cavity independent of the need for control by the surgeon. Approximately 250 ml is used in 15 minutes, which is the maximum time needed for diagnostic hysteroscopy. This medium is particularly safe as it is rapidly absorbed from the peritoneal cavity. Absorption of large amounts can produce tissue edema, and therefore the fluid should be sucked out from the pelvic cavity by laparoscopy or drained via culdocentesis. The major disadvantage is that D_5W does not allow for operative hysteroscopy, as bleeding will obscure vision. Because D_5W tends to flow freely through the tubal ostia and from the cervix, intrauterine pressure may not exceed 50 mm Hg; pressure of 100–110 mm Hg is required to visualize the tubal ostia and obtain adequate diagnosis. Because of these drawbacks, the author does not recommend the use of this distending medium for either diagnostic or operative hysteroscopy because it is inferior to Hyskon for viewing an operative field.

CO_2 Gas Insufflation

Although the visualization achieved with CO_2 distention is excellent, the operator must be aware of potential problems with this method of insufflation. Sophisticated instrumentation is needed for careful control of its delivery into the uterine cavity and for prevention of its escape from the cervix. There is always the possibility of gas intravasation with secondary hypercarbia, possible acidosis, and cardiac arrhythmias. Troublesome gas bubbles may form and obscure the view if there is fluid or mucus in the uterine cavity. CO_2 intrauterine insufflation is not suitable for operative hysteroscopy, as bleeding rapidly becomes a hindrance. With the introduction of the Hamou instrument and the insufflation equipment specifically designed for hysteroscopy, CO_2 is being used more frequently for diagnostic office procedures. The flow rate should be limited to 100 ml/min, and the intrauterine pressure should not exceed 200 mm Hg.

Indications for Hysteroscopy

Hysteroscopy is indicated in any situation where intrauterine visualization is essential for proper diagnosis of intrauterine pathology or when intrauterine hysteroscopic procedures are feasible. Indications include the following.

1. Proper identification of intrauterine filling defects diagnosed by hysterosalpingogram, such as synechiae, polyps, myomas, or foreign bodies.
2. Evaluation of the intrauterine cavity in cases of reproductive failure manifested by infertility or recurrent abortion.
3. Evaluation of recurrent abnormal uterine bleeding.
4. Location and retrieval of intrauterine foreign bodies.
5. Lysis of intrauterine adhesions.
6. Resection of intrauterine polyps or myomas.
7. Transcervical incision of uterine septa.
8. Investigation of cervical and uterine neoplasms.

The American Fertility Society's classification of intrauterine adhesions is shown in Table 18-1. The use of hysteroscopy for the delivery of transcervically placed sterilization devices, embryoscopy, and "tubaloscopy" is under investigation.

Contraindications

1. *Pelvic infection:* Patients with recent or currently existing pelvic inflammatory disease should not undergo hysteroscopy, as the procedure may exacerbate the infection.

2. *Heavy uterine bleeding:* Hysteroscopy is usually difficult when heavy uterine bleeding is present, and it fails to localize the source of bleeding under these circumstances. Dilatation and curettage (D&C) is often a more appropriate diagnostic and therapeutic approach to the problem. If indicated, hysteroscopy can be performed a few days after D&C when bleeding has already ceased or is minimal.

3. *Pregnancy:* Except for embryoscopy by the contact hysteroscope, hysteroscopy should not be performed in patients who are or who are suspected to be pregnant, as disruption of the pregnancy may occur.

TABLE 18-1. The American Fertility Society classification of intrauterine adhesions

Patient's Name ______ Date ______ Chart # ______

Age ____ G ____ P ____ Sp Ab ____ VTP ____ Ectopic ____ Infertile Yes ____ No ____

Other Significant History (i.e. surgery, infection, etc.) ______

HSG ____ Sonography ____ Photography ____ Laparoscopy ____ Laparotomy ____

Extent of Cavity Involved	<1/3	1/3 - 2/3	>2/3
	1	2	4
Type of Adhesions	Filmy	Filmy & Dense	Dense
	1	2	4
Menstrual Pattern	Normal	Hypomenorrhea	Amenorrhea
	0	2	4

Prognostic Classification HSG* Score / Hysteroscopy Score

Stage I (Mild) 1-4 ____ ____

Stage II (Moderate) 5-8 ____ ____

Stage III (Severe) 9-12 ____ ____

*All adhesions should be considered dense

Treatment (Surgical Procedures): ______

Prognosis for Conception & Subsequent Viable Infant*

____ Excellent (> 75%)

____ Good (50-75%)

____ Fair (25%-50%)

____ Poor (< 25%)

*Physician's judgment based upon tubal patency.

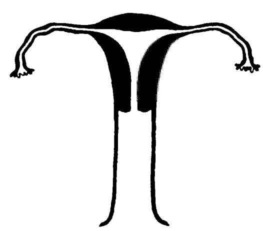
Recommended Followup Treatment: ______

Property of
The American Fertility Society

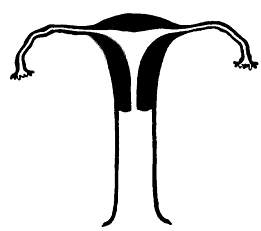
Additional Findings: ______

DRAWING

HSG Findings



Hysteroscopy Findings



For additional supply write to:
The American Fertility Society
2140 11th Avenue, South
Suite 200
Birmingham, Alabama 35205

From The American Fertility Society: The American Fertility Society classification of adnexal adhesions, distal tubal occlusion, tubal occlusion secondary to tubal ligation, tubal pregnancies, Mullerian anomalies and intrauterine adhesions. Fertil Steril 49:944, 1988. Reproduced with permission of the publisher, The American Fertility Society.

Technique

Visualization of the uterine cavity can be achieved by panoramic, contact, or microcolpohysteroscopy, but operative procedures can be performed only by the panoramic technique. The preoperative studies, the timing of the procedure, and positioning and preparation of the patient are aspects common to all techniques.

A preoperative history and a complete physical examination is essential to rule out any contraindications to the procedure, particularly early pregnancy. All types of diagnostic hysteroscopy can be performed in the office under the combination of systemic analgesia and a paracervical block, whereas operative hysteroscopy should be done in the operating room under general anesthesia.

The panoramic view of the intrauterine cavity is best obtained if the procedure is performed during the follicular phase. With experience the examination can be performed any time during the menstrual cycle. However, we do not recommend the procedure during menses to avoid the theoretical risk of producing endometriosis or carrying endometrial debris into the peritoneal cavity.

The patient is placed in the dorsolithotomy position, a bimanual examination is performed, and the urinary bladder is catheterized. The patient is then prepped and draped in the usual manner. General anesthesia must be administered unless it is known in advance that the procedure will be a brief diagnostic one. In this case, 50–75 mg meperidine (Demerol; Winthrop-Breon Laboratories, New York, NY) is given intravenously followed by a paracervical block using 10 ml of 1% lidocaine hydrochloride on each side. Five to ten minutes are allowed for the anesthetic to take effect. During this time, the instrument is assembled and the operator prepares for the hysteroscopic procedure.

When cervical dilatation is necessary, it should not exceed 8 mm to avoid leakage of the distending medium from around the sheath. After the endocervical canal and the uterine cavity are sounded, the sheath with the obturator in place is introduced to a level just beyond the internal cervical os. With the outer end of the sheath pointing upward to facilitate expulsion of the air from the uterine cavity, the obturator is removed, and the sheath is filled with Hyskon prior to insertion of the telescope. The telescope is inserted slowly while the assistant continues to inject Hyskon until no more air bubbles are seen coming out through the sheath. The telescope is introduced and fixed in the encasing sheath. Extra care should be taken at this time in handling the instrument to avoid accidentally removing it from the uterine cavity or advancing it too far, causing perforation of the uterus. The best way to keep the assembled instrument at the desired level is to hold it between the thumb and index fingers, with the fifth finger and the adjacent area of the hand resting against the patient's buttock. At the start, the assistant injects 5 ml of Hyskon to distend the uterine cavity, followed at intervals with 2–3 ml to maintain adequate intrauterine pressure for any diagnostic or operative procedure. Lavy et al.[5] have developed an electric pump for the instillation of Hyskon. This pump is controlled by the surgeon and delivers Hyskon at a constant, preset rate. If there is bleeding or excess cervical mucus, it can be easily washed out by pulling the hysteroscope back to the cervical canal, allowing the debris to escape through the opposite irrigating channel and from around the sheath at the external os.

Once the uterine cavity is adequately distended, a systematic exploration is performed. The fundus is first examined, and then the anterior, posterior, and lateral walls are scrutinized. Both tubal ostia should be identified; their recognition may be enhanced by increasing the intrauterine fluid pressure and observing the flow patterns of the Hyskon. While the hysteroscope is being withdrawn at the completion of the procedure, the cervical canal is thoroughly scanned. If laparoscopy is to be performed concurrently, we prefer to explore the pelvic cavity first, perform any operative laparoscopic procedures, and leave the laparoscope in place for simultaneous observation with both endoscopes should need arise during hysteroscopy. Findings are recorded and a drawing is preferably included. As an immediate postoperative follow-up, the patient is observed for any bleeding, major discomfort, or temperature elevation. A minor discomfort can be treated with mild analgesics, and spotting is ignored as it is common following hysteroscopy.

Contact Hysteroscopy Technique

The 6-mm contact hysteroscope can be inserted into the uterine cavity without cervical dilation. If the 8-mm contact instrument is used, slight cervical dilation is necessary. Baggish's[6] technique requires no distention medium and the hysteroscope is inserted directly. The endocervical canal is explored and the cervicouterine junction identified. In sequence, the left uterine wall, left tubal ostium, right wall, and right ostium are examined. Sweeping the scope from right to left and back permits examination of the fundus. Finally, the anterior and posterior walls are examined.

Microcolpohysteroscopy Technique

When used as a panoramic hysteroscope, the magnification used is 1×. The Hamou instrument is best employed with CO_2 as the distention medium. The CO_2 is preset at a rate of 50 ml/min, and the sheath and telescope are gently inserted into the cervical canal. As the canal is distended by the CO_2, the hysteroscope is gradually advanced, and the uterine cavity is systematically examined. For detailed examination of the endometrium, ostia, cervical glands, and any existing pathology, higher magnification of 20× to 60× may be employed. If for one reason or another the procedure is prolonged, the rate of gas flow should be decreased to 10–20 ml/min to prevent pertubation and stimulation of uterine contractions during this office procedure.

When used as a contact hysteroscope, the Hamou instrument should be used with 60× to 150× magnification along with supravital staining.

Complications of Hysteroscopy

Properly performed, hysteroscopy should be a low risk procedure with minimal complications. The most serious risks of hysteroscopy are related to general anesthesia or the distention medium. Complications resulting from diagnostic or operative hysteroscopy are rarely serious. Anesthetic complications are not different from those of other surgical procedures in which general anesthesia is used. As noted, if properly monitored, CO_2 insufflation should cause no problems. To avoid any risks, the operator should remember that there is always the possibility of gas intravasation with secondary hypercarbia, possible acidosis, and cardiac arrhythmias. Severe accidents associated with the use of Hyskon are extremely rare but may include adult respiratory distress syndrome, and lethal coagulopathy may occur with excessive quantities.[7] In addition, anaphylaxis manifested by hypotension can occur, as Hyskon is an antigenic polysaccharide. Prompt recognition and rapid intervention may prove to be life-saving. Both conditions may be avoided by careful limitation of Hyskon use to a maximum of 300 ml during a hysteroscopic procedure.

Complications that may be encountered during diagnostic or operative hysteroscopy include rupture of a hydrosalpinx, infection, uterine bleeding, and uterine perforation. Rupture of a hydrosalpinx may occur if the pressure generated by the distention medium is greater than what the agglutinated distal end of the damaged tube can hold.[8] Most hysteroscopists, including this author, have reported no infection in their large series of diagnostic or operative hysteroscopies.[9,10] Uterine bleeding during diagnostic hysteroscopy should never occur, but operative procedures are occasionally associated with bleeding from small vessels. No treatment is required; but if there is reason for concern, a Foley catheter balloon is used as a tamponade.

The incidence of uterine perforation during diagnostic hysteroscopy is reported to be 0.1%.[10] The perforation may be caused by the passage of the sound, dilators, or telescope, particularly if the uterus is retroverted or is scarred because of a previous infection. Very rapid flow of the Hyskon or very low CO_2 pressure with no uterine distention raises the suspicion that a uterine defect has been created. This type of perforation can be minimized if the hysteroscope is introduced and advanced under direct vision. During operative hysteroscopy, uterine perforation is a real risk; incidence varies between 2% and 10% depending on the experience of the surgeon as well as the type and extent of the procedure performed.[9]

Whenever perforation occurs, the instruments should be withdrawn and the patient observed. Unless bleeding is profuse or internal organ injury suspected, no further intervention is required. If there is reason for alarm, laparoscopy and, if necessary, laparotomy should be performed. Uterine bleeding resulting from perforation should never be treated with a Foley catheter balloon as it will enlarge the perforation site making the control of bleeding ineffective.

TABLE 18-2. Indications for hysteroscopy

Indication	No.	%
Routine infertility workup	117	44.25
Unexplained infertility workup	43	10.75
Intrauterine synechiae	96	24.0
Intrauterine filling defects other than synechiae	26	6.5
Double uterus (septate or bicornuate)	24	6.0
Diethylstilbestrol-associated uterus	34	8.5
Total	400	100

Applications of Hysteroscopy

Reports on the diagnostic value of hysteroscopy are conflicting, with many authors claiming increased accuracy of hysteroscopy compared with hysterosalpingography (HSG) in the diagnosis of intrauterine lesions.[11] Some authors have suggested that HSG should be completely supplanted by hysteroscopy.[12] In this context, the author[13] made a study to determine the diagnostic value of each of these two procedures and to establish criteria whereby each procedure might be properly used (Tables 18-2 and 18-3). The author concluded that HSG is an important screening procedure for the diagnosis of normal or abnormal uterine cavities and that hysteroscopy should be reserved for the confirmation and treatment of intrauterine anomalies revealed by HSG.

Abnormal Uterine Bleeding

To appreciate the abnormal, we must fully understand the normal. The appearance of the endometrium when panoramic hysteroscopy is employed varies with the phase of the menstrual cycle. In the proliferative phase, the endometrium is short, thin, and pink or tan, and it has few blood vessels. Under the pressure of Hyskon, the endometrium flattens and becomes pale. Secretory endometrium is tall, thick, and shaggy; it is velvety to touch and pink or tan in color.

TABLE 18-3. Uterine findings at hysterosalpingography and hysteroscopy

Uterine finding	Hysterosalpingography	Hysteroscopy
Normal uterine cavity	194	219 (194 + 25)
Synechiae	96	82
Arcuate uterus	26	20
Double uterus (septate or bicornuate)	24	24
Polyps	16	9
Fibroids	10	12 (10 + 2)
Diethylstilbestrol-associated uterus	34	34
Total	400	400

Small submucosal blood vessels may be sporadically seen.

Hysteroscopy has proved to be valuable in determining the cause of chronic uterine spotting or bleeding and in clarifying questionable findings based on hysterosalpingography.[13] Abnormal uterine bleeding constitutes the most common indication for any type of hysteroscopy. The rate at which intrauterine pathology is detected when panoramic hysteroscopy is employed to investigate abnormal bleeding may reach 85%.[13] Findings have included polyps, submucosal myomas, endometrial hyperplasia, foreign bodies, and in perimenopausal patients endometrial carcinoma. Extra care must be taken to differentiate polyps from the thick endometrium of the luteal phase. The polyp has a rounded, smooth, free end, whereas thick strips of endometrium have a shredded appearance and can be easily dislodged by a gentle stroke with the end of the hysteroscope. Myomas can be easily distinguished from polyps, as the latter have gentle undulations as the pressure of the distending medium varies compared to the fixation of the myomas.

Not only does hysteroscopy aid in establishing the correct diagnosis for abnormal uterine bleeding but direct visualization ensures complete removal of the lesion. Gribb,[14] performing hysteroscopy after D&C, observed in many instances the failure of curettage to completely empty the uterine cavity. Small polyps can be pulled out during hysteroscopy by catching the base with a special grasping forceps. Larger ones can be curetted by a special hysteroscopic curette under vision or by using the conventional curette directed blindly at the exact location. Immediate hysteroscopic reexamination is essential to confirm the adequacy of the procedure.

Small pedunculated or sessile submucous fibroids can be easily pulled out by the hysteroscopic grasping forceps. Larger fibroids may be successfully removed with use of a urologic modified resectoscope with Hyskon as the distention medium[15] (see Chap. 9). All intrauterine manipulations, particularly when electrocautery is employed, must be monitored by concomitant laparoscopy to ensure that no bowel is in contact with the uterus and there is no risk of perforation or burns. Postoperative bleeding can be controlled by use of a Foley catheter inserted into the uterus to accomplish uterine tamponade.[16] The balloon of a No. 16 catheter is distended with 5–10 ml of fluid until the bleeding stops. Larger uteri may need up to 20 ml when bleeding is relatively excessive. The balloon is left in place for 24 hours. Antibiotic coverage for such patients would be appropriate.

Infertility and Recurrent Pregnancy Loss

Before subjecting the woman in an infertile couple to any surgical procedure, a complete workup for both partners should be carried out. Barring any contraindications, a hysterosalpingogram is mandatory in the evaluation of infertility and recurrent pregnancy loss. When an intrauterine abnormality is detected, it is obvious that the nature of the lesion should be identified by direct visualization and dealt with by operative hysteroscopy. If HSG fails to demonstrate any intrauterine abnormality, hysteroscopy becomes a controversial issue. The author believes that after a complete infertility workup and when no apparent cause is found, laparoscopy combined with hysteroscopy is essential for completion of the investigation. The yield of the combined approach in patients with unexplained infertility is significant.[17] The lesions most commonly seen in infertile patients are polyps, myomas, synechiae, and septa. The significance of these lesions to infertility is not yet clear as few obvious cause-and-effect relations have been demonstrated.

By the same token, when no clear cause is found for recurrent pregnancy loss, hysteroscopy should be the final step to rule out the possibility of intrauterine pathology. Prior to assessment of the uterus, chromosomal studies should be carried out and both partners should be treated with tetracycline to eliminate the possibility of *Chlamydia* or *Mycoplasma* infection.

Intrauterine Foreign Bodies

Hysteroscopy has offered an effective approach to the management of lost foreign bodies in the uterus. Lost intrauterine devices (IUDs) and broken tips of a plastic suction curette can be easily retrieved. The procedure can be performed under local anesthesia as an office procedure. Extensive manipulation is rarely needed, as localization of the foreign body is usually immediate and accurate. Removal is accomplished using hysteroscopic grasping forceps or by removing the telescope and introducing the distally hinged alligator forceps.

Lysis of Intrauterine Adhesions

General anesthesia is essential for all intrauterine hysteroscopic surgical procedures. HSG is useful before all hysteroscopic surgical procedures as it shows the configuration of the uterus and reveals the exact location and extent of the filling defect. This factor is of particular importance in cases of intrauterine synechiae because of their multiple varieties and unpredictable extent. Such adhesions should always be suspected if there is a history of postpartum or postabortion curettage. We were able to confirm Hamou's observation that one can distinguish three types of intrauterine adhesion by their surface appearance: endometrial, myofibrous, and connective tissue.[18] The endometrial type resembles endometrium and can be easily broken up with the hysteroscope. The myofibrous adhesions can be treated by simple pressure with the hysteroscope but usually need to be severed by scissors; the muscular element is rarely the source of troublesome bleeding. The connective tissue type is the most severe and can be lysed only with sharp scissors; bleeding, if any, is usually minimal. Lysis of adhesions under direct vision is preferred to the traumatizing effect of the curette on the endometrium.

Excellent visualization under high intrauterine pressure with Hyskon is the key to a successful procedure. Bleeding spots can be eliminated by increasing the intrauterine pressure. It is good practice to withdraw the scissors when the operator encounters any bleeding so that the site and the extent of the problem may be evaluated. When approaching the fundus, the operator may find it necessary to use a hysteroscopic curette instead of scissors to avoid uterine perforation. Concomitant laparoscopy is recommended but not mandatory. Postoperatively, a No. 16 Foley catheter with a 5 ml bulb is used to separate the uterine walls for 1–5 days depending on the severity of the condition. An IUD will not serve any purpose, and its use should be condemned. Broad-spectrum antibiotics are given if a catheter is inserted into the uterine cavity or if a complication such as uterine perforation arises. Premarin (Ayerst, New York, NY) 2.5 mg is given twice daily for 30 days with Provera (Upjohn, Kalamazoo, MI) 10 mg daily added for the last 5 days. HSG is performed after the second menses to evaluate the results of surgery by comparison with the preoperative HSG.

Complete lysis of adhesions under direct visualization can be achieved in the great majority of women (Figs. 18-1 and 18-2). Among women who have no other cause for their infertility, 75% conceived and a term pregnancy rate as high as 90% was achieved.[19]

Excision of Uterine Septum

The septate uterus accounts for about 80% of all congenital müllerian anomalies seen at the Bowman Gray School of Medicine Infertility and Endocrinology Clinic.[9] It accounts for a small number of patients with infertility, recurrent abortion, or premature delivery. HSG does not differentiate between a septate and a bicornuate uterus. Laparoscopy enables the operator to evaluate the ex-

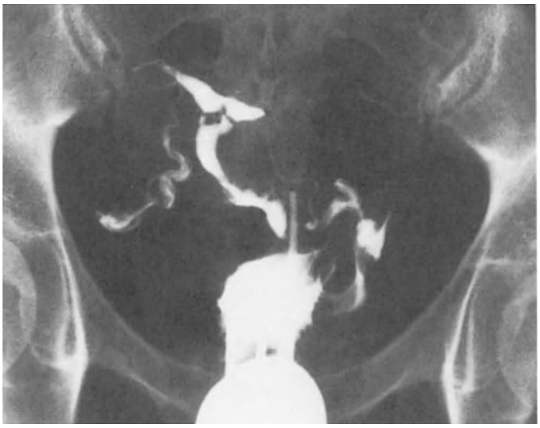


FIGURE 18-1. Hysterosalpingogram showing intrauterine synechiae.

ternal configuration of the uterus, and a normal fundus for a double uterus indicates that an intrauterine septum exists. In the past, surgical correction of this most common müllerian anomaly was accomplished by transabdominal metroplasty in accordance with the procedures described originally by Strassman,[20] Jones,[21] and Tompkins.[22] The operative hysteroscope has been introduced as an effective and safe instrument for uterine septum repair, with several reports showing that hysteroscopic metroplasty is indeed feasible.[23,24] In a retrospective study, the author showed that hysteroscopic metroplasty is preferable to the transabdominal procedure based on cost and morbidity considerations as well as on anatomic and reproductive outcome (Table 18-4).[9]

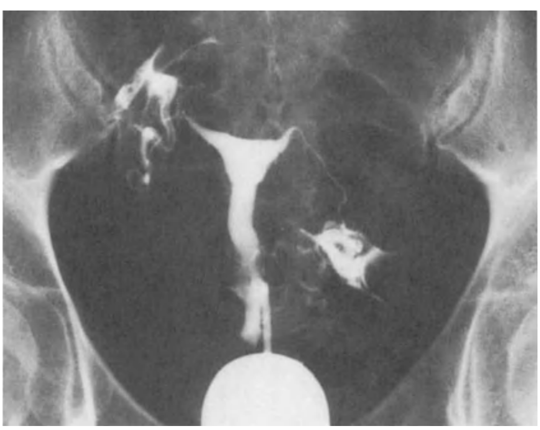


FIGURE 18-2. Hysterosalpingogram of same patient as in Figure 18-1, showing normal uterine cavity after hysteroscopic lysis of synechiae.

Operative hysteroscopy combined with laparoscopy should be carried out in the follicular phase of the cycle under general anesthesia. At the beginning, the hysteroscopic procedures are monitored by an assistant laparoscopist observing the location of the hysteroscope and instruments inside the uterine cavity using a dimmed light source of the laparoscope. Later, when more experience with the operation is obtained, the laparoscopic monitoring is abandoned except when difficulty is encountered. A rigid, 7-mm Storz hysteroscope is used with Hyskon as the distention medium. An average of 250 ml is used for each procedure, with a maximum of 400 ml on rare occasions.

The relatively fibrous and avascular septum resembles an inverted triangle with its base at the fundus. Incision starts at the apex with hysteroscopic rigid scissors (Fig. 18-3). The dissection is continued slowly and with utmost caution to avoid uterine perfo-

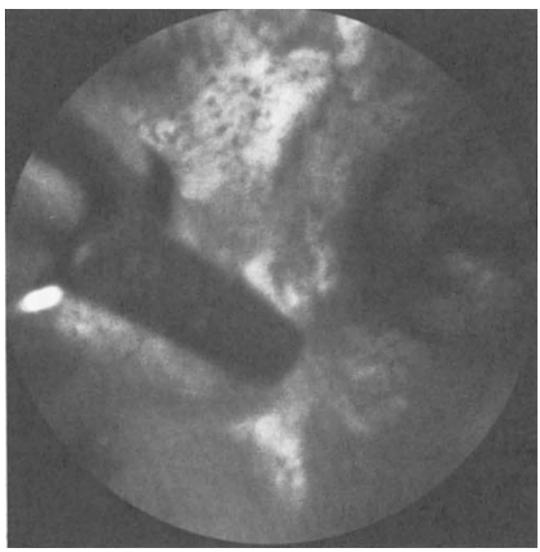


FIGURE 18-3. Hysteroscopic scissors cutting through uterine septum.

TABLE 18-4. Comparison in outcome between abdominal and hysteroscopic metroplasty

Procedure	No. of patients	Pregnancy rate (%)			
		Total	Term	Ectopic	Abortion
Tompkins	14	71	70[a]	10	20
Hysteroscopy	19	84	87	0	13

[a] Cesarean section.
Reprinted from ref. 9, with permission from The American College of Obstetricians and Gynecologists. (Obstetrics and Gynecology 1986;68:399.)

ration once the vascular fundus is approached. The best way to avoid uterine perforation is to be cautious once cutting starts into the base of the septum. At this point, the relatively fibrous and avascular septum gives way to myometrium, and small bleeding vessels can be easily seen. In addition, the whitish fibrous septum starts to change into a pinkish muscular color. Once these points are noted, it is time to terminate the procedure, particularly if the operating scissors can be moved freely across the top of the endometrial cavity from one ostium to another. After complete incision of the septum a No. 16 Foley catheter with a 30-ml bulb is inserted into the uterine cavity for 48 hours; the bulb is distended with only 5–10 ml of fluid.

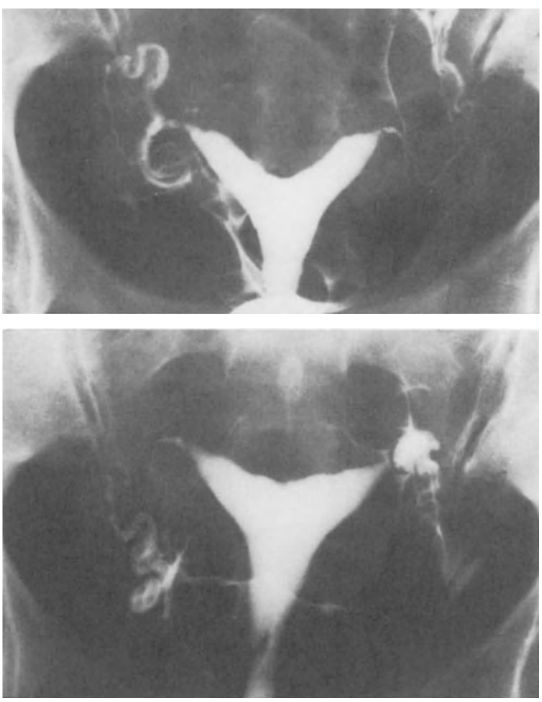


FIGURE 18-4. (Top) Hysterosalpingogram showing septate uterus. (Below) Hysterosalpingogram showing a normal uterine cavity after hysteroscopic excision of septum.

Postoperative estrogens are not routinely used, but doxycycline therapy is given intraoperatively and through the fourth postoperative day. All patients are instructed to use barrier contraception until a repeat HSG is performed during the first or second postoperative menstrual cycle. Contraception is then discontinued once the complete incision of the septum is confirmed by the postoperative HSG (Fig. 18-4). Because the procedure does not require abdominal or uterine wall incisions, vaginal delivery can be achieved without the risk of uterine rupture. Hysteroscopic laser resection of uterine septa is described in Chapter 19.

Potential Applications of Hysteroscopy

Most hysteroscopists foresee a tremendous future for hysteroscopy, not only in terms of diagnosis but also for surgical correction of myriad conditions. As noted in the following chapter, many exciting applications of operative hysteroscopy are already on the horizon including laser ablation of the endometrium because of menometrorrhagia (see Chap. 19), transcervical tubal sterilization, embryoscopy, "tubaloscopy," and evaluation of uterine and cervical neoplasia. Before long, it is expected that these techniques will become routine procedures for many interested and motivated gynecologists.

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19
Hysteroscopic Laser Surgery

JAMES F. DANIELL

Advances made by gynecologists in the field of operative hysteroscopy have paralleled similar interests in the use of surgical lasers. Improvements in optics, light sources, hysteroscopes, and lasers have led several gynecologists to begin investigating the use of lasers for certain intrauterine surgical procedures. To date the primary use of lasers at hysteroscopy has been in the treatment of menorrhagia with the neodymium:yttrium aluminum garnet (Nd:YAG) laser. This procedure has now been approved by the Federal Drug Administration (FDA) and is being clinically performed by many gynecologists experienced at hysteroscopy and trained in laser surgery. Other, newer lasers, such as the argon and the potassium titanyl phosphate (KTP) lasers, are still under early clinical investigation for hysteroscopic laser procedures.

The preceding chapter addressed diagnostic and nonlaser operative hysteroscopy. This chapter will present clinical experience and results with the Nd:YAG laser for hysteroscopic ablation of the endometrium and the early clinical investigations of the argon and KTP lasers for other forms of hysteroscopic surgery.

Lasers Investigated for Hysteroscopic Surgery

To date, four surgical lasers have been evaluated for hysteroscopic surgery: CO_2, Nd:YAG, argon, and KTP lasers. Each of these lasers has different distinctive characteristics based on their individual wavelengths. The basic information regarding these lasers has been outlined in previous chapters.

The CO_2 laser was the first surgical laser investigated for hysteroscopic use. In 1979, a prototype hysteroscope designed by Eder Instrument Company and Sharplan Laser was evaluated in both animal models and clinical trials (unpublished data) at Vanderbilt University Medical School. Although several models were developed, the technical problems could not be overcome. These difficulties included the need for using CO_2 as a distending medium, the accumulation of significant smoke with firing inside the small uterine cavity, problems with alignment of the helium-neon beam through the small operating channel of the hysteroscope, and bleeding difficulties. In addition to our early work at Vanderbilt, similar work was carried out in Israel by Tadir et al.[1] CO_2 hysteroscopic equipment has never been commercially produced even though it was possible to design a satisfactory working model. If and when fibers become commercially available to allow delivery of the CO_2 laser energy through a flexible fiber, it may be possible to do successful intrauterine surgery with this laser. Even then, it would be necessary to work with CO_2 distention, which would carry the risk of CO_2 embolus and produce significant intrauterine smoke, which could obscure vision.

The Nd:YAG laser is the one most investigated for hysteroscopic laser surgery.

Goldrath et al.[2] first reported their experience ablating the endometrium using the Nd:YAG laser. Since that time, many authors have reported a similar experience.[3–6]

In 1985, clinical investigations of the KTP/532 nm laser (Laserscope, San Jose, CA) in gynecology was begun at HCA Westside Hospital, Nashville, TN.[7,8] Soon thereafter, the argon laser was also investigated for hysteroscopic surgery.[9] The KTP and the argon lasers have similar characteristics, with wavelengths that are only 32 nm apart. They both can be delivered through small flexible fibers and work effectively in CO_2, dextran, or saline. The argon and the KTP laser penetrate no more than 2 mm in depth and can incise or vaporize tissue discretely much better than the Nd:YAG laser without as much scattering of the beam or tissue coagulation.[10]

The newest application of Nd:YAG laser surgery that is being tested hysteroscopically is the attachment of synthetic sapphire tips to the end of the laser fiber. Attachment of a sapphire probe dramatically reduces the scatter inherent with the Nd:YAG. The laser effect on tissue depends on the type of tip used. For instance, a sharply coned cutting tip is useful for lysis of adhesions and particularly for incision of the uterine septum. A ballpoint tip is used to coagulate a broad but shallow area, such as that left after various intrauterine procedures (e.g., removal of a submucous myoma with a broad base). A tip shaped like a chisel is a very good all-purpose instrument that allows some cutting as well as destruction and coagulation of tissue beneath the level of the endometrium. Loss of the scatter effect is detrimental if the desired effect is one of endometrial ablation. Therefore, there seems to be no role for the sapphire probes in that area.

The indications for the sapphire probe Nd:YAG system for intrauterine surgery include septal incision, removal of the base of a myoma with excellent hemostasis, allowing for mechanical removal of the myoma itself after the base has been separated, removal of certain polyps, and possibly lysis of intrauterine adhesions. The sapphire probe tip has been used in conjunction with CO_2 as the distending medium because the amount of smoke generated is very low; it has also been used with glycine, saline, and high-molecular-weight dextran. There is a tendency for the latter to carmelize and cause some difficulties in visualization if the laser is energized before the tip is directly applied to the surface of the tissue. However, with a bit of practice, this problem can be totally obviated, and the operator can enjoy the excellent distending properties of dextran. *A cautionary note:* The laser tip should not be cooled with CO_2 but with liquid because the flow of CO_2 to cool the tip is in excess of safe limits for use in the uterus regardless of the distending medium chosen (Corson S: personal communication).

Use of the YAG Laser for Ablation of the Endometrium

There are between 500,000 and 700,000 hysterectomies performed each year in the United States, and fully one-fourth of them are for menorrhagia with no other uterine pathology.[4] Annually, 1.7 billion dollars of health care funding is spent in the United States on hysterectomy and its related complications.[11] Data from multiple studies now seem to indicate that many of these patients can be satisfactorily treated with the Nd:YAG laser using the unfocused diffusing and penetrating characteristics of the beam. The endometrium can be destroyed down to the myometrium so that there is no endometrial regeneration from the basalis layer. In essence, it allows patients to undergo a simple outpatient hysteroscopy and accomplish control of uterine bleeding with minimal discomfort or expense.

Obviously, Nd:YAG laser treatment for menorrhagia can be a very cost-effective procedure by eliminating the need for some hysterectomies. Instead of removing the uterus, the patient retains it, ensuring the psychologic and possible physiologic benefits that accrue. It is critical to select and counsel patients who are seeking treatment with the Nd:YAG laser for menorrhagia. All patients must have completed their childbearing and have a desire to avoid hysterectomy. They must have a benign endometrium with no known organic cause for their bleeding (e.g., a submucosal fibroid). Initially, the FDA required sterilization in all patients, but that requirement has been dropped because it has been shown that Nd:YAG ablation itself causes bilateral tubal occlusion at the cornu in a high percentage of cases in addition to destroying the endometrium.

Candidates are usually those who have undergone multiple dilatation and curettages (D&Cs) and have persistent uterine bleeding unresponsive to medical therapy, which might include cyclic progesterone, androgens, combination birth control pills, antiprostaglandins, or ergotrate-type drugs. Our patients basically fall into two groups, one group being patients with medical contraindications to hysterectomy with significant bleeding. This category includes patients with severe obesity, heart or renal disease, or blood dyscrasias, or who need chronic anticoagulant therapy. The second group of patients are bleeding to an extent unacceptable to them and thus seek out treatment that eliminates or reduces the bleeding but allows them to retain the uterus and avoid major surgery.

Patient Pretreatment Evaluation

All patients who are to undergo this procedure are required to have a D&C or endometrial biopsy within the previous 6 months. We also perform office hysteroscopy to evaluate the cavity preoperatively, thereby ensuring that at the time of the Nd:YAG laser ablation no significant polyps or submucosal fibroids have gone undetected by previous blind D&C. Office hysteroscopy, as presented in the previous chapter, and selected endometrial biopsy performed at the same time have been very cost-effective and efficient in accurately evaluating the preoperative endometrial cavity. These procedures offer minimal expense and discomfort to the patient. After the cavity has been determined to be normal and hyperplasia or cancer has been ruled out, the patient is placed on a pretreatment protocol to shrink the endometrium. Either danazol (Danocrine; Winthrop-Breon Laboratories, New York, NY) is recommended at an 800 mg/day oral dosage for a minimum of 4 weeks prior to surgery, or an injectable gonadotropin-releasing hormone (GnRH) analog (Lupron Injection; Tap Pharmaceuticals, North Chicago, IL) 0.2 ml subcutaneously is given daily. Both these drugs produce a hypoestrogenic state and thereby induce a thinned endometrium. A thin endometrium offers a greater chance for successful destruction of the basalis. In addition, it reduces the potential for intraoperative bleeding during the hysteroscopy, which would make the procedure more difficult to complete.

All procedures are done on an outpatient basis under general anesthesia. Exceptions are made in very ill patients or those with compromised medical status. The procedure can be done under a paracervical block with light intravenous sedation if necessary.

Surgical Technique

Nd:YAG laser ablation of the endometrium normally takes 45–60 minutes. This length of time is needed because of the small diameter of the fiber (0.6 mm) and the need to very carefully treat each contiguous area of the endometrium to obtain the desired effect of total ablation. Saline has been the medium of choice for distending the uterine cavity, as it cools the uterine surface and has less risk of complications from intravenous absorption than either CO_2 or dextran. Dextran can be used, but the total volume of dextran infused should be kept to less than 300 ml to eliminate the possibility of complications from dextran intravenous overdose. If the procedure is attempted under CO_2 distention, smoke is a problem as well as the potential risk of CO_2 embolus. After evaluating several types of hysteroscopes, the author recommends those with three ports opening on the distal end near the lens. They allow introduction of saline near the lens as well as removal of saline through another channel while simultaneously introducing the laser fiber. A new steerable hysteroscope is under investigation that may eliminate some of the problems with properly directing the fiber into the lateral, anterior, and posterior walls of the uterus.

There are three distinct methods for performing the procedure. One involves actually touching the fiber to the endometrium and treating contiguous areas. The second is a no-touch technique similar to airbrushing in which the fiber is held very close to the tissue and slowly moved over the endometrium in a systematic fashion. The laser is set on 50–60 watts, and the entire surface of the endometrium is treated from each ostia down to the lower endocervical canal. Care is taken not to treat too vigorously in the lower cervix for fear of causing subsequent cervical stenosis.

A third method, the dragging technique, is easy to accomplish. However, one must be careful to never fire the laser while pushing the fiber forward, only while pulling the fiber back. This technique can eliminate the potential for inadvertent perforation into the myometrium with occult injury to the bowel. A combination of touching, stippling, and airbrushing is recommended to accomplish the entire treatment of the endometrium. The advantages of the direct touch contact are that you get a greater depth of penetration, although it is offset by the increased risk for fluid absorption and the need to cleave the fiber intermittently throughout the procedure because of damage to the tip from direct contact to the myometrium. The advantages of the no-touch technique are that you reduce fluid absorption potential and reduce the need for recleaving the fiber. However, by not touching the fiber to the endometrium, you decrease the depth of penetration and thereby may be reducing the ability to totally destroy the endometrium. Intermittently, as the tip melts, the fiber must be removed from the hysteroscope, cleaved and repolished, resterilized, and reinserted.

Results of the Nd:YAG Laser Procedure

Goldrath et al.[2] initially reported a very high success rate in a large number of patients. More recent investigators have not reported such a high incidence of total amenorrhea, probably reflecting the fact that most investigators do not treat as aggressively with Goldrath's cratering technique. The author has found that patients who are perimenopausal have shown excellent results, whereas those patients who are younger have been more likely to have persistent postoperative bleeding. It probably results from the higher estrogen levels in the younger women and the regenerative powers of the basalis layer of the endometrium. Our results in over 100 patients have shown 75% total amenorrhea in those who are over 40 years of age and 60% total amenorrhea in those patients under 40.

It is important to counsel patients preoperatively so that they are aware that total amenorrhea may not be accomplished with one treatment. Patients should be routinely informed of this fact; and in the initial consultation, multiple treatments may be offered at no extra charge if the patient is unhappy with the results of the initial treatment. To date, only 8 of 100 patients have been retreated. A third treatment was required on only one of those eight before accomplishing adequate reduction in bleeding.

A saline infusion system using 5 L of saline instilled under pressure from a hanging pressurized bag with constant monitoring of the volume has allowed us to perform the procedure effectively. A urinary catheter should be inserted in all patients and attention paid to the volume of fluid used and the volume returned from the procedure. Constant irrigation of the endometrium with minimal pressure distention reduces intravascular fluid absorption. First, coagulation around each ostia is recommended so that intraperitoneal tubal reflux of saline can be eliminated. After treating each ostia, the endometrium is symmetrically treated down to near the external os. In practice, it is a good idea to treat all the way down until the hysteroscope falls out of the cervical canal. The patient is usually kept on hypoestrogenic therapy for 2 weeks after surgery to delay the return of estrogen production until early postoperative fibrosis and scarring can effectively destroy the basalis and reduce the potential for regeneration of the endometrium. Almost all patients are treated on an outpatient basis and return rapidly to their normal activities.

Postoperative follow-up consists of cervical dilatation at 1 and 2 months to monitor the potential for cervical stenosis and hematometra formation. It has not occurred in any of the author's patients but was an early problem in the Goldrath et al.[2] series.

Complications of the Technique

Intraoperative complications include those of hysteroscopy, such as perforation, infection, or bleeding. In addition, fluid overload and bowel or bladder laser injury are real and potentially dangerous problems. Late complications include bleeding, hematometra, and failure of the therapy to totally correct the menorrhagia. For further reading on Nd:YAG laser safety, the reader is referred to the suggested reading list in Chapter 16.

Future of Nd:YAG Laser Ablation of the Endometrium

It now appears that ablation of the endometrium with the Nd:YAG laser is clinically efficacious and is finding its way into the mainstream of gynecologic practice. Because the Nd:YAG laser will pass through clear substances, the possibility of using a hysteroscopic balloon may make this procedure even safer. Basically, the hysteroscope could be inserted in a clear balloon to be inflated inside the endometrial cavity. The laser energy could then pass through the balloon surface to affect the endometrium without damaging the balloon. The obvious advantages are that there will be no risk of fluid absorption, and intraoperative bleeding would be eliminated. Further investigation of these balloon devices is ongoing.

Synthetic sapphire laser focusing tips have been used with the Nd:YAG laser to perform ablation. This method potentially eliminates some of the problems in penetrating deeply with the fiber but, on the other hand, may diminish the ability of the laser energy to diffuse and penetrate deep enough to totally destroy the basalis.

Numerous workshops are now available throughout the United States, allowing interested physicians to become familiar with these new techniques. It must be strongly emphasized that gynecologists need to be very experienced hysteroscopists and have a good understanding of laser physics and tissue interaction before undertaking endometrial YAG laser ablation. The YAG laser is potentially a very dangerous laser because of its depth of penetration and the fact that the beam is invisible. It is mandatory that all interested gynecologists maintain very careful safety protocols when using the YAG laser—to protect both the patient and the surgeon. Because of the risk to the operator's eyes from the backscatter of the YAG laser, it is recommended that all YAG laser ablations be performed using the television monitor. This practice eliminates the possibility of some of the YAG laser energy leaking through the protective eye filters and producing long-term damage to the retina of the surgeon (see Chap. 16).

Hysteroscopic Laser Treatment of Uterine Septum

Another surgical procedure that has gained FDA clinical approval in gynecology is treatment of the uterine septum with laser energy. As presented in the preceding chapter, it appears that the day of abdominal metroplasty for uterine septa has passed. Several authors have reported their success using hysteroscopic scissors[12,13] or a resectoscope[14] for treating uterine septa. With the ability to direct laser energy into the uterine cavity to vaporize tissue came the capability to treat uterine septa with this laser energy. Both argon and KTP lasers can be used to discretely vaporize tissue under hysteroscopic control through small flexible fibers. These lasers have similar tissue effects. They both penetrate approximately 2 mm and can vaporize with excellent hemostasis without lateral thermal damage. Early clinical results have been reported by the author, who is carrying out further clinical trials.[9]

There are many advantages to using laser energy to destroy the septum. Because the laser coagulates as it vaporizes, a totally bloodless field is maintained and there is no need to inject dilute vasopressin (Pitressin; Parke-Davis, Morris Plains, NJ) transabdominally into the uterus. The procedure can thus be carried out under saline instead of dextran because bleeding is not a problem. This technique eliminates the risk of dextran absorption. The laser fiber vaporizes for no more than a depth of 2 mm, and it is not necessary to push the fiber into tissue for it to be accomplished. This factor makes it possible to sculpt out the septum one layer at a time up to the fundus without risk of perforation as when scissors or a resectoscope are used. Using a resectoscope or scissors leaves a somewhat shaggy top of the fundus because these instruments are working at right angles to this area. The laser, however, can vaporize all of the little peaks and valleys that remain at the top of the fundus after the septum between the anterior and posterior wall has been cut.

Selection of Patients

Uterine Septum

The patients should have the standard evaluation for recurrent abortions, and all other possible causes should be eliminated or treated. All procedures should be performed under general anesthesia with a laparoscope in the abdomen for confirmation that the uterus is not bicornuate and for control of potential penetration through the wall of the uterus during the laser firing. All procedures should be done in the early proliferative menstrual phase to improve visibility and reduce bleeding during the procedure.

A setting of 10 watts is used, and the smaller-diameter laser fiber, which gives greater vaporization and depth of cut, is preferred (400 μm for the KTP laser and 300 μm for the argon laser). The naked fiber of the Nd:YAG laser is inappropriate for vaporizing a uterine septum, as all that occurs is coagulation and charring of the septum. Synthetic sapphire tips, when adapted to the end of the Nd:YAG laser, result in effective division of the septum in a fashion similar to that accomplished with the KTP or the argon laser. However, the Nd:YAG laser is not effective for vaporizing the base of the septum at the top of the fundus, and for this reason either the argon or the KTP, instead of the Nd:YAG fiber with synthetic tips, is recommended. In addition, the synthetic sapphire tips for focusing the Nd:YAG laser are rather expensive when compared with the easily cleavable and reusable flexible fibers of the other two lasers.

The fiber is introduced through the operating channel of the hysteroscope; and using a saline infusion system, the apex of the septum is incised transversely. One must be careful not to wander into the myometrium on either the anterior or the posterior wall of the uterus. Once the septum is vaporized up to the level of the tubal ostia, the abdominal observer needs to very carefully watch for the amount of light that transmits through the myometrium. It is particularly easy to do with the fiberoptic light bundle removed from the laparoscope. Because both the argon and the KTP laser are visible light lasers, there is a bright lightbulb effect that can be seen through the myometrium. When the fundus has a uniform transmission of laser light, the operator knows that the maximum vaporization depth has been reached. It is usually possible at this point to see both tubal ostia in one panoramic view through the hysteroscope when it is sitting at the level of the internal os. An airbrush technique is used at this point to very carefully vaporize the peaks and valleys of the remaining broad portion of the pyramid-shaped septum. The procedure is terminated, and no intrauterine devices are inserted. Postoperative estrogen therapy is given for 21 days followed by 10 days of oral progestin. The patient then experiences withdrawal bleeding and is seen back in the office for a hysteroscopy at approximately 6 weeks postoperatively.

The use of early postoperative hysteroscopy has the advantage of allowing direct evaluation of the endometrium. It is then possible to mechanically lyse any early postoperative adhesions in a fashion similar to early second-look laparoscopy after major pelvic surgery.

The author's experience from an initial series of patients has shown excellent results with no intraoperative complications.[9] The patients in whom the uterine cavity was inspected hysteroscopically showed no significant intrauterine adhesions and excellent healing postoperatively (see Table 19-1). It is recommended that the patients avoid conception for at least 3 months to allow healing.

Fiberoptic laser energy delivered through the hysteroscope is an excellent bloodless method for destroying a uterine septum without damaging the endometrium, with minimal risk of complication and good early follow-up.

TABLE 19–1. Hysteroscopic resection of uterine septi with fiberoptic laser energy, West Side Hospital, January 1986–December 1988

Total patients treated	32
Second look hysteroscopy 6 weeks later	24
Adhesions seen	1
Patients attempting pregnancy	25
Conceived	19
Pregnancy ongoing or liveborn at term	17 (89%)
Spontaneous abortions	2 (11%)

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Submucosal Fibroids

Solitary submucosal fibroids can be removed hysteroscopically. The author's attempt to remove them with the Nd:YAG laser has resulted in the fibroid being charred and not vaporized. Small fibroids can be totally vaporized using the KTP or argon laser. However, a combination of removal of the bulky portion of the fibroid with a resectoscope and the use of laser energy to vaporize the base of the fibroid in the myometrial bed is recommended. Because the laser energy takes a longer period of time to remove bulky fibroids, it seems much simpler to use a resectoscope to shave off the major bulk of the fibroid, thereby saving time and avoiding potential complications during the operation. Again, a concomitant laparoscopy is recommended to reduce the risk of uterine perforation during the procedure. Unfortunately, not many patients are candidates for resection of a submucosal fibroid, as most patients have other fibroids in other parts of the uterus. The author's experience has been limited to only a handful of cases, but satisfactory results with no intraoperative or postoperative complications have been accomplished. Our follow-up period is too short to know if any of these submucosal fibroids will regenerate and become clinically significant again.

Asherman's Syndrome

The number of referrals to tertiary care facilities for treatment of Asherman's syndrome has steadily fallen during the 1980s in this author's experience. The Asherman cases evaluated by the author have basically fallen into two categories: those that can easily be broken up with a curette or hysteroscopic forceps, and those that have dense fibrotic obliteration of the endometrium unresponsive to any therapy. The laser of choice for treating Asherman's syndrome has been either the KTP or the argon. These lasers are helpful for discretely vaporizing the roots of the adhesions on the anterior, lateral, or posterior walls of the uterus. A combination of scissors or blunt probing with the hysteroscope tip is recommended to break up most of the adhesions followed by curettage over the remaining portions. Finally, the laser fiber is used to vaporize the bases of the adhesions. In these cases, postoperative estrogen–progesterone therapy is recommended with follow-up office hysteroscopy at 6 weeks.

Sterilization

The Nd:YAG laser can be seen to occlude the tubal ostia when endometrial ablation is performed. It seems possible that hysteroscopic discrete application of the Nd:YAG laser energy around only the ostia of each tube could be a form of effective sterilization that would avoid invading the peritoneal cavity. Discussion with various laser manufacturers has been carried out, and studies are beginning to investigate this possibility. Because the laser fiber is so small in diameter (600 μm), a hysteroscope as small as 3.8 mm in external diameter has been designed as a prototype for office hysteroscopic sterilization with the laser. In the past, hysteroscopic sterilization with cautery had to be abandoned because of inadvertent bowel burns from transmural passage of the cautery energy to bowel. Because the Nd:YAG laser fiber produces its tissue effect without the need for placing the fiber into the ostia, it seems that it would be a safer method of occluding the ostia. Our technique of occluding the ostia has been to place the fiber about 2 mm lateral to the ostia and circumferentially fire around it. Under direct vision, the tissue will be seen to constrict down, and the ostia will immediately close. Ongoing clinical trials in Third World countries will investigate the long-term effects of hysteroscopically occluding the ostia with Nd:YAG laser energy. It may be that the day of laparoscopic tubal ligation will wane in the near future if it becomes possible to use energy from the YAG laser to successfully occlude tubal ostia in an office setting with a small-diameter hysteroscope.

Conclusions

Much more work is needed with all the surgical lasers before their true role in hysteroscopic surgery can be determined. We are entering an exciting era of medicine in which many new lasers are on the horizon. The popularity of more aggressive use of hysteroscopy for operative techniques combined with the arrival of newer, more sophisticated lasers should lead to a very exciting time for gynecologists interested in endoscopic surgery.

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20
Urethrocystoscopy

ALFRED E. BENT and DONALD R. OSTERGARD

In 1893 Howard Kelly of the Johns Hopkins University Department of Gynecology devised a technique for inspecting the bladder. It consisted of a tube with a handle. When the tube was inserted into the bladder and the patient was placed in the knee-chest position, air filled the bladder. A head-lamp reflected light into the tube; and with the bladder distended with air, the walls could be examined under direct vision. From those humble beginnings modern urethrocystoscopy has evolved.

Definitions

Urethroscopy is the evaluation of the urethra using a 0° lens as exemplified by the urethroscope described by Robertson in 1973. Cystoscopy is the visualization of the bladder using a 30° or 70° lens with the cystoscope. Neither instrument can adequately assess both organs.

Indications in Gynecology

Both instruments have applications in gynecology for a number of conditions. Urethroscopy is indicated for the following: urinary incontinence, recurrent urinary tract infection, suspected urethral diverticulum, urinary tract bleeding, irritative urethral and bladder symptomatology, vesicovaginal or urethrovaginal fistula, urethral polyps, urethral condyloma, and intraoperative use in identifying the urethrovesical junction and its response to repair procedures. In addition to these indications, the cystocope is used to assess interstitial cystitis including biopsy, perform laser therapy, stage cervical cancer, assess intraoperative suture placement during incontinence procedures, and evaluate bladder integrity.

Equipment

The various endoscopes and lens systems for gynecologic use are listed in Table 20-1 and shown in Figures 20-1, 20-2, and 20-3. In addition, a light source and fiberoptic cable are required. For photography and video documentation, various systems are available including miniature video cameras (Fig. 20-4) and flash generators. High intensity light sources are needed, and a fluid-filled light cable is very useful. A high resolution monitor, video recorder, and camera for photography are needed for documentation (see Chap. 11). For fluid infusion, standard intravenous infusion systems are satisfactory. A standard laboratory incubator will keep the fluid at body temperature. For carbon dioxide, various low pressure systems are available for attachment to the urethroscope. Carbon dioxide should not be used for cystoscopy as will be explained later. Because the procedures are generally performed in women while awake, a com-

TABLE 20-1. Gynecologic endoscopes and lenses

Urethroscope
Lens, 0°
Sheaths, 18F and 24F
Operating urethroscope (arthroscope)
Biopsy forceps
Grasping forceps
Cystoscope
Lenses, 30° and 70°
Sheaths (17F for observation, 21F for biopsies)
Biopsy forceps
Grasping forceps

fortable examining chair or table is helpful. Urethral dilators (sizes 12F to 24F) may be needed, as well as 2% lidocaine gel (Xylocaine; Astra Pharmaceutical Products, Westboro, MA), cleansing solution, and a teaching attachment (Fig. 20-5) if video is not used.

Urethral Examination Including Dynamic Functional Assessment

The urethral meatus is cleaned with a disinfectant solution. With the infusion medium flowing, the urethroscope is introduced into the urethra. Topical anesthetic is not used because of possible irritative effects on the urethral mucosa. At first, the angle of insertion is generally straight in. Depending on the patient's anatomy, angulation may then be downward or upward. By keeping the center of the urethra in constant view, the urethral lumen is followed so as not to damage the mucosa. If the urethra is too small to allow insertion of the urethroscope, dilators must be used to gradually increase the size of the urethral meatus to allow examina-

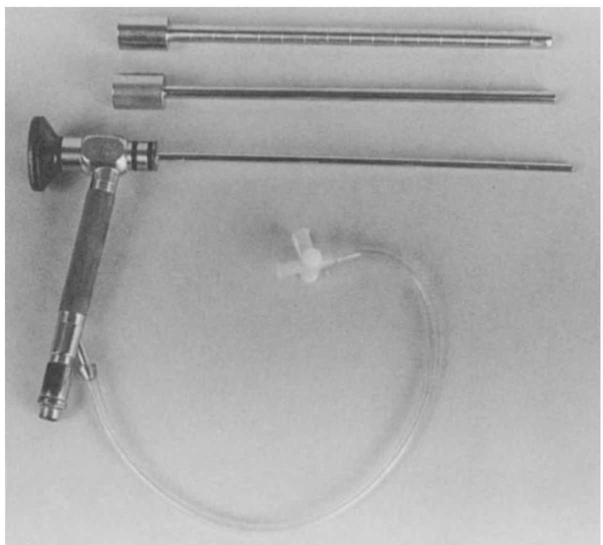

FIGURE 20-1. Urethroscope with 18F and 24F sheaths.

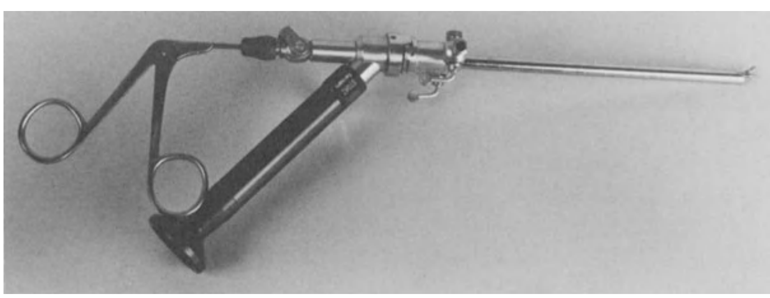

FIGURE 20-2. Operating urethroscope with biopsy forceps.

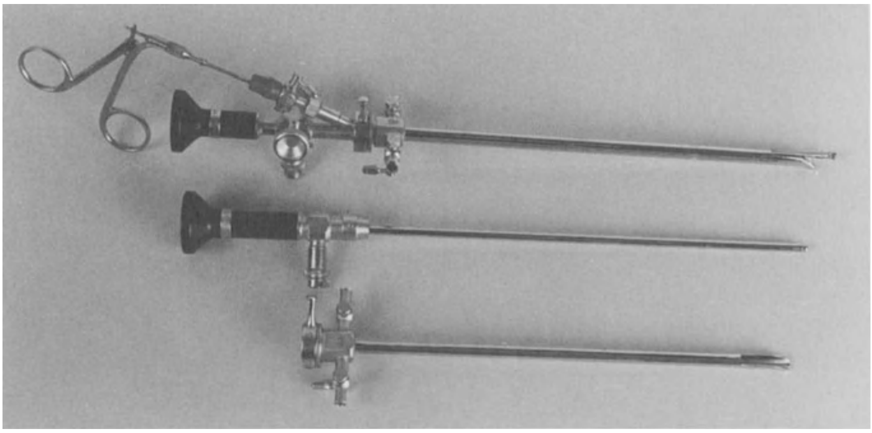

FIGURE 20-3. Cystoscope with 17F sheath; cystoscope and 21F sheath with operating channel; and biopsy forceps.

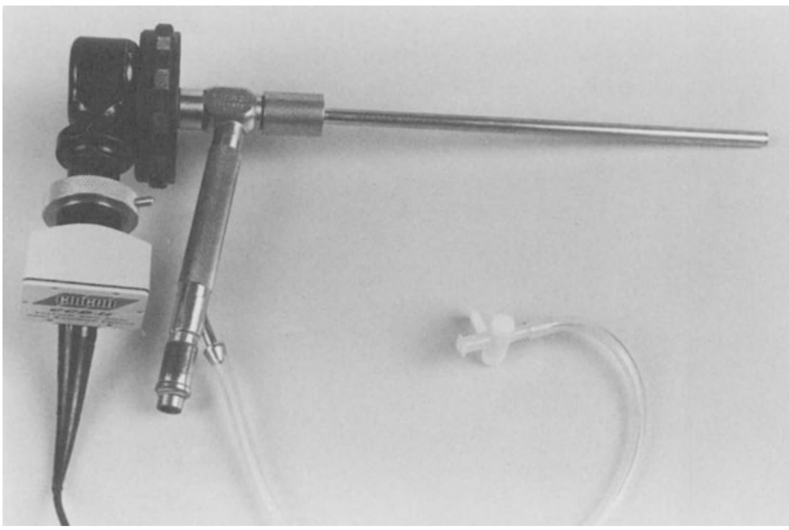

FIGURE 20-4. Urethroscope with video camera attached. (Courtesy of Circon ACMI, Stanford, Connecticut.)

FIGURE 20-5. Teaching attachment for endoscopes.

tion. In this case, the mucosa will show the effects of the dilatation, which must be considered in reporting the findings. The infusing medium distends the urethra, which is examined as the endoscope is slowly moved toward the urethrovesical junction (UVJ). One observes for pallor, redness, exudate, abnormal orifices or enlarged gland openings, fronds, condyloma acuminata, polyps, and other abnormalities.

When the UVJ is reached, the flow of infusing medium is stopped and the UVJ is examined for the presence of fronds, condyloma, or polyps. The flow is resumed, and the trigone and ureteral orifices are observed. With the bladder empty the ureters are readily seen just beyond the UVJ at the extremes of the interureteric ridge. They are found by looking downward at a 30° angle and slightly lateral in either direction. Ureteral function is demonstrated by observing the egress of fluid as the ureter opens, closes, and retracts. The remainder of the bladder cannot be adequately assessed with the urethroscope, although some abnormalities that may be seen in the base of the bladder include bladder tumors, foreign bodies, stones, cystitis, and trabeculation as the bladder fills.

The endoscope is withdrawn into the proximal urethra until the UVJ closes one-third of the way. The dynamic function of the UVJ and the proximal urethra are now assessed in response to hold commands and to the stress of the Valsalva maneuver and coughing. Hold maneuvers are carried out by asking the patient to squeeze her rectal sphincter and then to hold her urine. The expected response in the normal patient is for the UVJ to close. The urethroscope is further withdrawn until the UVJ is only one-third open, and the patient is then asked to bear down, as in having a bowel movement, and to cough hard two or three times. The normal response is closure. The patient with genuine stress incontinence will not be able to close the UVJ while holding. The UVJ usually opens in response to the Valsalva maneuver and coughing.

A record of the amount of solution or gas infused is maintained as the bladder is allowed to fill, noting the patient's first sensation of filling, fullness, and maximal capacity. The endoscope is positioned so the UVJ is one-third closed; during filling complete closure should occur over the end of the instrument. First sensation will occur at 50–150 ml with both carbon dioxide and saline, fullness at 150–250 ml with carbon dioxide and at 200–350 ml with saline, and maximum capacity at 250–300 ml with carbon dioxide and at 350–550 ml with saline. With the bladder subjectively full, the UVJ hold and stress maneuvers are repeated. Normally the UVJ should close over the end of the urethroscope with each of these maneuvers. The patient is then asked to void. If a detrusor contraction is generated or if an uninhibited detrusor contraction occurs, the urethra opens all the way from the UVJ to the meatus. When the patient is asked to stop the contraction, the urethra should close. The unstable bladder is diagnosed if a spontaneous detrusor contraction occurs or if the patient cannot inhibit a voluntary contraction.

With the bladder comfortably full (a small amount of fluid or gas may have to be released at this point), the vaginal finger compresses the UVJ while the infusing medium is restarted. As the urethra distends, the urethroscope is slowly withdrawn from the UVJ toward the meatus. This portion of the examination is the most uncomfortable, and the patient should be forewarned of the 10 seconds of temporary discomfort. Exudate and diverticular orifices are more easily seen especially when urethral massage is done just above the end of the urethroscope. The urethra is palpated through the vaginal mucosa against the urethroscope for the presence of diverticula or other abnormalities.

The lubricated cystoscope is introduced into the bladder without the obturator in position. There is little or no resistance at the meatus, and the curve of the urethra as discovered during urethroscopy is followed. The air bubble is readily seen at the bladder dome. Insertion of the endoscope may cause some temporary sharp discomfort that passes quickly. The bladder is systematically examined working from the air bubble to the trigone along each clock face position beginning with 12 o'clock to 4, then 11 to 8, and finally the trigone and the remainder of the bladder base.

Controversy: Gas Versus Fluid

There is controversy whether CO_2 gas or normal saline solution should be used for urethroscopy. The advantages of CO_2 are that it is not messy, it produces rapid distention of the urethra and bladder during infusion, and it facilitates use of CO_2 laser therapy in urologic abnormalities (see section on use of lasers, Chap. 16). The disadvantages are that there may be a bubbling effect, which may obscure visualization, the canisters of CO_2 may need replacing, CO_2 gas may be irritating to the urethral and bladder wall, and rapid infusion may cause painful distention of the bladder. The stimulus to void with CO_2 may be so intense as to provoke uninhibited detrusor contractions giving the false diagnosis of detrusor instability. The maximum volume of CO_2 gas infused appears to be about 200–300 ml, whereas that for saline is 350–550 ml. The advantages of a saline solution are that it distends the bladder more slowly and more naturally than gas and thus may be more physiologic, and the same solution can be used for examination of the bladder. The major disadvantage is the spillage that occurs, although the proper use of towels minimizes the problem. Visualization through gas or liquid medium appears to be of similar quality. The electrolyte solution can be infused via gravity drainage through an ordinary intravenous administration setup. Measurement of detrusor pressure during endoscopy is not thought to add significant information to the procedure.

Normal Findings

Anatomic Observations

The anatomic length of the female urethra is 3–5 cm, with a diameter of 8–10 mm, and sounds to 24–30F. The urothelium is pale pink and smooth. Posteriorly there may be a longitudinal ridge, "the urethral crest." The UVJ is round or horseshoe-shaped. Just inside the UVJ and slightly laterally placed are the ureters, which are best viewed when the bladder is empty. The boundaries of the trigone are the ureters, interureteric ridge, and the internal urethral meatus. This area has a more intense pink and granular surface than the remaining bladder wall. The posterior bladder wall lies over the uterus, and as a result it appears as two large pouches, with cervix and fundus indenting the bladder wall in the midline. The bladder wall is smooth and pale white to pink in color with its vessels seen easily under the mucosal surface. When viewing the trigone with the cystoscope the area appears reddish compared to the pink color seen through the urethroscope.

Functional Observations

The normal urethra readily allows passage of the urethroscope unless the patient experiences some unusual discomfort. At midurethra, pulsations may be visualized coincident with a palpable pulse, and the urethral mucosa opens and closes partially over the end of the urethroscope. The UVJ should close over the end of the urethroscope during hold, strain, and cough maneuvers. The ureters empty urine from the kidneys into the bladder approximately every minute and can be seen to open and close. As the bladder fills, the UVJ gradually closes over the end of the urethroscope. In response to voluntary voiding, the UVJ opens widely and the whole urethra can be visualized. Once cessation of voiding occurs, the urethra closes again.

Abnormal Findings

Anatomic Observations

Many common abnormalities have already been emphasized during the description of the urethroscopic technique, but a few specific features bear emphasis. The urethral meatus may be too small to allow passage of the urethroscope, and dilatation is required using the small urethral dilators.

Chronic Urethritis

The urethral mucosa may be red or may be covered with exudate exiting from the posterior paraurethral glands and ducts along the entire urethral length. There may be fronds (thin feathery structures with a central capillary) or polyps (pedunculated bulbous pink structures) generally located in the proximal urethra or at the UVJ.

Estrogen Deficiency

The urethra with a pale mucosal lining suggests hypoestrogenism as seen in the postmenopausal patient.

Fibrosis

A urethral lumen or UVJ that is pale and rigid and does not respond to hold maneuvers indicates urethral scarring and fibrosis with probable denervation. The entire urethra is frequently viewed from the meatus to the UVJ in this patient. In effect, the urethra is now a functionless, rigid, scarred, fibrotic drainpipe. A standard repair for incontinence is unlikely to work in this patient.

Trigonitis

A trigone with thick pale epithelium and tongue-like extrusions toward the urethral opening indicates trigonitis, which frequently occurs in association with urethritis.

Stricture

Narrowing of the female urethra, when present, occurs almost always at the meatus, where a calibration of less than 14F usually causes some difficulty for the patient. Proximal urethral stricture or midurethral stricture may result from prior urethral surgery, such as repair of a urethral diverticulum.

Caruncle

A caruncle is a benign polypoid fleshy projection from the posterior terminal female urethra and consists of connective tissue, blood vessels, and inflammatory cells covered by epithelium. It may be asymptomatic or painful, is red in color, measures 0.5–1.5 cm, and usually occurs singly.

Urethral Prolapse

A urethral prolapse is an eversion of urethral mucosa through the external meatus. It is soft and circular, and completely surrounds the urethral meatus. Its color varies from crimson to pale pink. The condition, which may be painless or painful, or present with bleeding, usually occurs in premenarchal and postmenopausal patients. Treatment with topical estrogen and local sitz baths is usually curative.

Urethral Polyp

Urethral polyps present as small, pink or fleshy structures on a slender stalk usually arising from the posterior urethra. They are ulcerated at times and occasionally present as multiple polyps. Symptoms include bleeding, frequency, and slight pain or dysuria.

Cystitis

Cystitis is a nonspecific term for bladder inflammation. Acute infection of the bladder mucosa is associated with pink to red blotchy patches along the bladder wall. Interstitial cystitis is associated with red petechial spots along the superior and lateral bladder walls and may progress to large defects, Hunner's ulcers, or frank bleeding. The patient complains of urinary frequency, bladder pain on filling, and decreased bladder capacity. At cystoscopy the bladder capacity may be diminished. After fill and refill of the bladder the petechial areas appear. Pale or bleeding ulcerated areas are seldom seen, but maximal bladder distention under anesthesia may incite considerable mucosal bleeding.

Cystitis Cystica

Cystitis cystica is a benign condition comprised of clear or translucent mucosal cysts measuring up to 5 mm in diameter. It is thought to be secondary to a low grade chronic inflammation.

Cystitis Glandularis

The lesion cystitis glandularis, a proliferative cystitis secondary to inflammation which may be associated with neoplasia, is characterized by the formation of nodularity or small, discrete elevations. Like cystitis cystica, the small lesions are located over the trigone around the urethral and ureteral orifices but may involve other areas of the bladder as well.

Foreign Bodies and Stones

Calculi are infrequent in the urethra and bladder except when contained in a diverticulum. The short female urethra permits ready passage of bladder stones. Women with stone disease present with bladder stones only 2% of the time. A foreign body is almost always a suture from a prior surgical procedure.

Trabeculation

The occurrence of smooth ridges with occasional cellules and sacculations along the bladder wall at or near bladder capacity is termed trabeculation. The etiology may be detrusor dyssynergia associated with an unstable bladder, although in older women the significance is uncertain. The inside of a bladder diverticulum or large saccule should be examined for stones and tumor.

Congenital Abnormalities

Ureteral duplications that are complete usually have the second ureter on the interureteric ridge with the lower orifice closest to the UVJ draining the upper portion of the kidney. Rarely the urethra is duplicated.

Tumors

Bladder tumors appear as discrete papillary lesions, frequently at the bladder base and lateral to the ureters.

Functional Disorders

During strain maneuvers in the patient with genuine stress incontinence, the UVJ is seen to descend and open. This patient may not be able to close the UVJ with hold maneuvers. As the bladder fills in the patient with detrusor instability, the UVJ may open widely and be associated with partial loss of bladder contents. If this patient tries to hold her urine during a voluntary or spontaneous detrusor contraction she is frequently unsuccessful.

Biopsy Techniques

Biopsy of distal urethral lesions can be done without endoscopy. The area is injected with local anesthetic using a 30 gauge needle with 1% lidocaine, and biopsy is performed in the usual manner. Bleeding may be controlled with pressure, cautery, Monsel's solution (ferric subsulfate), or silver nitrate.

An intraurethral lesion or a lesion present at the UVJ requires assessment with the urethroscope. Biopsy can be performed using an arthroscope with a central biopsy channel and 0° lens. Bleeding from the site is controlled with pressure or cautery.

Tumors or other lesions of the bladder can be biopsied using the operating cystoscope. Diathermy will not be tolerated at the trigone without anesthesia. A 4% solution of lidocaine instilled into the bladder for 15 minutes along with a bladder pillar block may allow easier biopsy maneuvers.

Anesthesia

Urethroscopy is best performed and usually well tolerated without local anesthetic. When urethral dilatation or cystoscopy is performed, topical 2% lidocaine gel is applied to the dilator or endoscope, or is placed on a cotton-tipped applicator and inserted into the urethra 5 minutes prior to the procedure. Anesthesia for distal urethral biopsy or removal of a caruncle is adequately achieved with local lidocaine injection using a 30 gauge needle. Biopsy or removal of urethral polyps and other urethral lesions requires an anesthetic. Lidocaine gel 2% can be inserted into the urethra with a cotton-tipped swab or the cone-shaped applicator that comes with the tube. For the rare patient unable to tolerate endoscopy and urethral dilatation, a bladder pillar block is administered. It is also useful for bladder biopsy procedures described above. The pillar block is given with 5 ml of 1% lidocaine injected into each bladder pillar approximately 2 mm deep so as to raise a wheal. With the cervix present, the bladder pillars are at 2 and 10 o'clock at the junction of the cervix and vagina. In the absence of the cervix, the injection is administered at the urethrovesical junction at the 4 and 8 o'clock positions. After 5 minutes the effect should be evident.

Intraoperative Use of Endoscopy

Most uses for intraoperative urethroscopy or cystoscopy involve an incontinence procedure. Suture placement at the UVJ during retropubic urethropexy can be assessed by the assistant surgeon using the urethroscope. Diverticula and fistula repair may require the urethroscope for identification of landmarks and adequacy of repair. The cystoscope is used to place suprapubic catheters under direct vision, to observe for presence of sutures in or near the bladder, and to rule out fistulas. Either instrument may be used to assess the patency of the ureters by observing for excretion of dye-colored urine following the injection of indigo carmine.

Laser Therapy in Urogynecology

Urethra

The CO_2 laser is frequently used to treat meatal lesions, especially caruncles and condylomas. Periurethral cysts have been drained with laser incision. The technique for meatal lesions or distal urethral lesions is to cleanse the area with topical antiseptic, inject 1% lidocaine or equivalent using a 30 gauge needle, and, using 10 watts of power and a 1.0–1.5 mm spot size, vaporize the lesion or create an opening large enough to ensure adequate drainage. No catheter drainage is required postoperatively. The patient administers saline soaks, topical antibiotics, and a topical anesthetic agent until the area heals.[1]

Bladder

Endoscopic laser surgery has been used to treat interstitial cystitis, carcinoma in situ, other benign and premalignant bladder lesions such as condyloma and cystitis glandularis, and overt cancer of the bladder, ureter, and kidney. The most frequently used laser in urology is the neodymium-yttrium aluminum garnet (Nd:YAG) laser, which is ideally suited for the transurethral treatment of bladder pathology.[2] This laser has the capacity to photocoagulate tissue in a fluid or gaseous medium with minimal blood loss. It may be done with the patient awake under local anesthetic as an outpatient, although more frequently it is still performed under a general or regional anesthetic. Lesions of transitional cell carcinoma less than 3 cm in size are especially suited for Nd:YAG laser treatment. The lesion is photocoagulated at the periphery, followed by treatment of the superficial elements (fronds), and then the remaining tumor. A combination of laser and transurethral resection of superficial tumor can be carried out, in which case the laser is used to photocoagulate the base of the resected area. The recurrence rate for these tumors with laser therapy is approximately 15%, which is comparable to the recurrence rate with traditional resection procedures.

Interstitial cystitis refractory to all other conventional and conservative measures has been treated with the Nd:YAG laser delivered through a continuous-flow cystoscope using a power of 25–30 watts with a pulse duration of 8 seconds. A nontouch technique is used with the laser fiber tip 3 mm from the tissue. All inflamed areas including a wide margin and the bladder trigone are coagulated. The results of treatment are encouraging; and although relapses occur, 80% of patients have 6–12 months of relief.

Carcinoma in situ of the bladder can be treated similarly to interstitial cystitis with good results—no tumor recurrence in 24 months. Other benign or premalignant intravesical lesions may also be treated with the Nd:YAG laser.

Invasive bladder cancer has been managed with resection and Nd:YAG laser treatment to the base of the tumor. This treatment has been restricted to patients who are not candidates for surgical therapy or who have refused cystectomy. Effective ablation has occurred in patients with stage Bl tumors, but results are discouraging if tumors are stage B2 or greater. There is ongoing research into the use of photodynamic treatment of transitional cell carcinoma of the bladder.

Another endoscopic use of the laser is the pulsed dye laser fragmentation of ureteral calculi. The laser fiber is passed through an operating channel of a ureteroscope in patients in whom calculi are too low for extracorporeal shock wave lithotripsy and too high or resistant to extraction under vision by standard basket extraction techniques. The stone is fragmented by the pulsed dye laser application, and the fragmented particles are then passed spontaneously.

Summary

Both the urethroscope and the cystoscope are used for assessment of functional and anatomic abnormalities of the lower urinary tract. Adequate evaluation of these structures requires training in the use of these endoscopes and complements the standard clinical and urodynamic diagnostic procedures used for assessment of lower urinary tract disorders in women. Treatment modalities include cauterization, application of Monsel's solution, or laser therapy. Laser therapy is frequently applied using the Nd:YAG laser within the bladder and the CO_2 laser to correct urethral abnormalities. New horizons in treatment include the advancement of photodynamic treatment for urogynecologic abnormalities.

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Legal Issues Relating to Gynecologic Endoscopy

STEVEN R. SMITH

Legal issues related to operative endoscopy and laser laparoscopy include qualifications for practice, informed consent for treatment, professional liability (malpractice), hospital practice, equipment failure, treatment of minors, and confidentiality. Legal issues raised in gynecologic endoscopy generally follow legal principles applicable to other areas of medical practice. However, in some instances the unusual characteristics of pelviscopic surgery and laser laparoscopy require special attention or consideration. For example, the relatively recent development of these techniques and the special skills they require imply that some formal specialty training should be completed before they are undertaken.[1,2]

In this chapter, we review the major legal principles that influence gynecologic endoscopy and examine their special application to operative and laser laparoscopy, or pelviscopic surgery. In most instances, we cannot be completely certain of the application of legal principles to these medical techniques because there are relatively few cases that have clearly defined the law in these areas. However, the basic principles involved are clear, and we can fairly well define the outlines of the law that will apply to gynecologic endoscopy. Note that some caution is called for in applying these principles in any given state, as described at the end of the chapter.

Qualification for Practicing Gynecologic Endoscopy

In one legal sense, the M.D. or D.O. degree (as part of a license to practice medicine) is the only educational qualification required to engage in the practice of pelviscopic surgery or laser laparoscopy. A state license permits the holder to practice virtually all kinds of medical or surgical procedures.

The broad statement of authority to practice is, however, misleading. There are substantial ethical and legal limits on physicians practicing in areas in which they are not fully competent, even if the state license permits a full range of practice. For example, a physician "shall . . . obtain consultation . . . when indicated."[3]

The practitioner who practices gynecologic endoscopy without formal training also risks malpractice liability if that practitioner's quality of care does not conform to that of a well qualified professional. Such a professional is "holding himself or herself out" as an expert and will probably be held to the standard of care of an expert.[4] A physician not well qualified to undertake endoscopic practice must refer the patient to someone who is adequately qualified. The physician who fails to do so is risking malpractice liability.

The emphasis should be some kind of *for-*

mal training in pelviscopic surgery and laser laparoscopy.[5] Simply reading about new procedures or hearing them described is not sufficient. There should be a period of supervised clinical training in the new techniques. Even a practitioner who has had some formal training in gynecologic endoscopy should undertake additional training when a new technique is undertaken that is a significant departure from past practice. Again, the element of adequate supervision by existing experts in the field is of great importance.[6]

The specific form of training in terms of its duration, type, location, and intensity will depend on the complexity of the procedures to be learned and the experience of the practitioner seeking the training. Ideally, the training should lead to a broadly recognized certification by a well respected professional organization or by an accredited institution (hospital or school of medicine). Certification by itself, however, does not ensure an adequate education and thus does not ensure legally adequate training. "Box top" or "correspondence" certification would be of little value if the adequacy of training of a physician engaged in gynecologic endoscopy were challenged in a legal proceeding. In obtaining training, the professional should ensure that any formal standards for training in gynecologic endoscopy procedures have been fully met.[7]

In addition to the ethical imperative and liability-avoidance value of obtaining good training before pelviscopic surgery or laser laparoscopy is undertaken, such training is generally necessary before these procedures may be undertaken in hospitals or other institutions. Indeed, as we shall see, institutions should have policies and procedures in place to ensure that only those properly trained are permitted to perform gynecologic endoscopy within the institution.

Informed Consent

The primary purpose of the ethical and legal requirement of informed consent is to implement an important personal interest: the right of patients to determine what will be done to their bodies (the right of autonomy privacy).[8] Although informed consent is essentially a legal doctrine, it may have medical benefits as well by preparing the patient for medical or surgical procedures, or increasing trust in physicians.[9]

Although we often think of informed consent as of relatively recent origin, legal cases involving liability for the failure of consent can be traced back more than 200 years.[10] One of the clearest statements of the requirement of consent is now nearly 75 years old. "Every human being of adult years and sound mind has the right to determine what shall be done with his or her own body and a surgeon who performs an operation without his [or her] patient's consent commits [a tort] for which he [or she] is liable in damages. . . ."[11] In modern times, the troublesome part of the doctrine has been in defining what information must be given in order for the consent to be "informed" and therefore valid.[12]

Broadly stated, consent is required before any medical treatment or diagnosis is undertaken.[13] Consent for minor, safe, and noninvasive testing or treatment is commonly presumed from the fact that a patient seeks medical attention or does not object to the tests or treatment. As diagnosis or treatment becomes more risky or invasive, however, full consent is no longer presumed, and consent must be preceded by sufficient information for the patient to make a decision to accept or refuse the diagnosis or treatment. Pelviscopic surgery and laser laparoscopy are within the group of procedures that would require specific informed consent.[14] Other treatments, including giving many prescription medications, also require some form of informed consent.[15] Although informed consent need not be in writing in most states, a written document or notation does help prove what information was given and that the patient did indeed consent.

The doctrine of informed consent sometimes appears to be a mass of ever changing technical legal rules and regulations, and indeed the law of informed consent is somewhat complex.[12] We will review some of the legal rules in this section. The physician need not remember a bundle of legal rules, however, because the application of the doctrine of informed consent is relatively simple if the reason for informed consent is kept in mind: *Informed consent is intended to give the patient sufficient information to permit an intelligent decision on whether to accept the proposed treatment or diagnostic procedures.*[16]

The information generally considered to be essential to informed consent includes the following.[17]

1. Description of the procedures or treatments to be undertaken
2. Review of the benefits and the risks or hazards of this treatment or procedure
3. Statement of the alternatives to the proposed treatment or procedure
4. Consideration of the consequences and risks of rejecting treatment or diagnosis.

Although the specific information may change depending on the procedure to be performed (or the drug to be prescribed), the basic question is always the same: what information would a person in this patient's position need to have in order to make a well informed decision?[18] The decision-making basis for requiring this information is clear: It tells the patient what is recommended and why, the potential problems with that recommendation, and the other options available to the patient.

Because the consent process is intended to provide information to the patient on which a decision can be made, it is important that the information be imparted in a way that will be meaningful to the individual patient.[19] Complexity of language is a good example of an area in which the needs of the patient must be considered. It would do little good to provide a patient with a description of a proposed procedure in complex terms she could not understand.[20]

Specifics of Disclosure

The question of what specific information must be disclosed is a difficult one. The question ordinarily arises in relation to the question of what risks should be identified. On one hand, we want to give the patient as much useful information as necessary. On the other hand, too much information may mislead by needlessly frightening or overloading the patient. Thus it is impossible to answer the question "what information should be disclosed," with mathematic precision. As a general matter, a risk should be disclosed as the probability or the magnitude (harm it may cause) increases. A small risk of death should be disclosed, whereas much larger risk of a transient rash may not need be disclosed. The importance of a risk must also be measured in terms of the individual patient to the extent possible. For example, even a small risk of harm to the nerves controlling the hand is likely to be of considerably greater concern if the patient is a surgeon than if she is an attorney.

As a general matter, a physician is not required to redisclose information of which the patient is already aware or that is common knowledge. It has been said, for example, that the remote risk of death from anesthesia is such a risk.[21] However, for several reasons caution is warranted in determining not to disclose information to a patient because the patient probably already knows it. First, physicians may overestimate the knowledge of patients. Second, "common" knowledge is often only partially right at best, and the process of informed consent is a chance to correct mistaken beliefs. Third, some patients may emotionally deny some information. This situation can be a problem particularly when patients refuse or delay diagnostic or treatment procedures and such a delay can be dangerous. The consent process may be a way of confronting this denial mechanism.

The obligation to provide information about the consequences of refusing the proposed procedure should not be neglected. This obligation is of significant importance when a patient is rejecting or delaying treatment (or a diagnostic process), and the delay may significantly harm the patient. An example of the importance of this obligation is the case in which a patient refused a Papanicolaou smear, developed cancer that went undetected until a cure was impossible, and sued the physician who had recommended the tests for failure to warn her of the potential fatal consequences of her refusal.[22,23] Although this case goes further than most in suggesting liability (after all, it is reasonable to assume that the patient should have been aware of the risks she was taking), it does underline the importance of disclosing even the risks of refusal.

When Informed Consent Is Not Necessary

There are a few widely accepted exceptions to the informed consent requirement.[24] The two major exceptions are commonly referred to as the "emergency exception" and the "therapeutic privilege." Both of these labels are somewhat misleading if taken literally.

The emergency exception is the common sense rule that when someone is incapable of providing consent and immediate treatment is necessary to avoid death or serious injury, the treatment may be undertaken without informed consent.[25] This exception does not apply every time emergency medical treatment is necessary, only when there is a real emergency and there is no way to obtain informed consent (or refusal). It is important to emphasize that there are *two* requirements for depending on the emergency exception: the absence of any way of obtaining informed consent *and* the existence of a health emergency. Ordinarily, when a patient is incompetent to give (or refuse) consent, the next of kin or guardian gives (or refuses) consent. The emergency exception generally does not apply when it is possible to contact the next of kin or guardian for consent.

Also, the emergency exception does *not* apply when a competent patient refuses consent to important treatment. In such cases, the physician or hospital may seek a court order to provide treatment.[26]

The therapeutic privilege permits information to be withheld from patients when providing that information would significantly and adversely affect their health. For example, if a patient is likely to become extremely agitated as a result of hearing about certain risks associated with surgery, the information about those risks might be withheld. The decision to withhold information in many circumstances should be made in consultation with the patient's family.

Great caution should be exercised in claiming the therapeutic privilege. The physician invoking it should be prepared to demonstrate clearly the necessity of withholding the information and that serious harm was likely to ensue from giving the information to the patient. The fact that the patient would have refused treatment if given the information is decidedly *not* an adequate reason to invoke the privilege.[21]

Other Values of Informed Consent

In addition to the formal legal aspects involved, the informed consent process may be used to accomplish several other important goals. It can be used, for example, to lower the unrealistic expectations of patients that a procedure is foolproof or guaranteed, to increase patients' feelings of participation in their own health and health care, and to encourage patients to discuss expectations and concerns about treatment.[27] In short, it is an opportunity to improve communication with patients. As such, the process of obtaining informed consent should not be merely a dry, legalistic exercise but, rather, an important part of the total treatment of the patient.[28]

Minors and Other "Incompetent" Patients

The concept of informed consent assumes that the patient is legally competent to make medical care decisions. Of course, in some circumstances patients are not competent to make their own decisions because of their age (minors) or mental condition.[29] When someone is incompetent, the law provides for a substitute decision maker in the form of a guardian or next of kin.[30]

Traditional common law principles held that minors were not legally able to consent to treatment for themselves. Minors were generally those under the age of 18 or 21 (or somewhere between in some states).[31] A few minors are considered "emancipated" from their parents because of early marriage or a permanent separation from the parental home. They are treated as adults for the purpose of consenting to medical care.[32] Despite considerable evidence that adolescents are able to be effective decision makers well before the age of 21 (or 18), as a general proposition the decision to consent is still vested in the parents or guardians of minors.[33–37] However, there are exceptions to this general rule. A number of states have adopted statutes that give minors the right to consent to treatment in some areas, commonly including contraception and pregnancy counseling except abortion, some kinds of obstetric care, and substance abuse treatment.[38] The U.S. Supreme Court has also recognized minors' rights to consent to the use of contraceptives and abortions in some circumstances.[39,40] The issue of informing parents of abortions and contraceptive use remains at issue, however, although the consequences of such "squeal laws" may not have yet been fully realized.[39,41] Furthermore, at the time of this writing there is reason to believe that the Supreme Court may significantly limit abortion rights.

Process of Obtaining Informed Consent

Ideally, the informed consent process for significant treatment or diagnostic procedures should include a written document that sets out the basic information needed by the patient to make a decision to undergo the proposed procedure plus at least two oral conversations with the patient (and in most cases the patient's family). One conversation should be used to present the information concerning the proposed procedure and to invite questions; the second is used to answer questions and secure consent. It is also desirable for the physician to make notes as soon as possible after the discussion, summarizing oral conversations with the patient.

Obviously it is not always possible, or necessary, to undertake this formal two-conversations-plus-written-consent process. When there is a need for immediate action or the procedure proposed is not risky or invasive, a much more informal consent process is in order. Even in these circumstances, however, where consent is obtained more quickly or informally, the information necessary to make a decision should be imparted to the patient. Again, it is desirable to keep notes of the conversation with the patient.

Application of Informed Consent Principles to Gynecologic Endoscopy

The above principles, applied to pelviscopic surgery and laser laparoscopy, suggest several informed consent guidelines for the practitioner,[42,43] including the following:

1. Except in the most extraordinary circumstances (involving an emergency situation in which the patient is not competent and delay would be harmful), *written* informed consent should be obtained from the patient. Copies of the written consent should be retained with the patient's hospital records, the medical records, and the physician's records.[44] A copy of the consent could also be given to the patient.
2. The written consent should be supported by oral discussion regarding the procedure. The physician should ensure that all of the patient's questions have been answered.
3. Ideally, except in emergencies, at least two discussions should be involved in the consent process. A consent form should be left with the patient at the first meeting and should be signed at the second. If possible, a member of the patient's family (at the option of the patient) should be present during one of the conversations. Consent should be obtained by the physician, not an assistant or nurse.

4. Special caution should be exercised when a patient is a minor or is not clearly competent. The state law regarding the "power" to consent to the medical procedure in question must be reviewed.

5. At a minimum, the patient should be told (1) the nature of the procedure proposed, (2) the risks and benefits of that procedure, (3) alternative procedures or approaches, and (4) the consequences of not undergoing the procedure.

6. Consent should be obtained for diagnostic procedures and treatment, and for anything that is significantly invasive, including many prescription drugs.[45] (The consent process for most drugs can be fairly informal.)

7. The informed consent process should be used to reduce unrealistic expectations of the patient. It should be clear that pelviscopic surgery or laser laparoscopy are significant procedures that should not be undertaken lightly, that favorable results cannot be guaranteed, that there are risks associated with them, and that there will be some pain and a period of convalescence.[14]

8. Special consent must be obtained if the patient will be a research subject or not receiving generally accepted ("standard") medical care. Special consent should be obtained if the patient will be used in teaching. (The issue of teaching and research subjects is described later in this chapter.)

Example of an Informed Consent Document

The following is a draft of a consent document that might be used for endoscopic surgery. No single document can be universally relied upon as an informed consent document for all occasions, and consent must be undertaken with the law of the state in which the procedure will be performed kept in mind. Therefore this is not a "model" consent form.[46]

Although there are differing views on this issue,[47] it is wise to develop informed consent documents tailored to specific procedures. Note that this form provides only basic information, and it would have to be accompanied by additional oral information. In a few instances this informed consent document contains blanks that the physician must complete.

Consent to Endoscopic Surgery

I understand that Dr. ____________________ is recommending that I undergo endoscopic abdominal surgery in order to [*here describe the purposes of the endoscopy*].

Description of the procedure. I understand that during this procedure the surgeons will first perform a diagnostic examination using the endoscope. This will require creating one or more incisions (cuts) through the abdomen ("belly") near the umbilical area ("belly button"). This incision (or incisions) will probably be about one-half inch long (each if there are more than one), although the length of the cut can vary. Other small incisions may be required to insert other instruments.

I understand that the process that will occur next will depend on the findings during the first part of the operation. If in their judgment, treatment can be undertaken using the same endoscopic tube, the doctors will use the endoscope to try to correct any problems.

It is possible, however, that the doctors may decide that it is best to perform major surgery (laparotomy), which will require a large incision in my abdomen.

A hospital stay will be required. If so, it is usually short with endoscopy, but is likely to be longer if abdominal surgery is required.

Risks. I understand that endoscopy is a relatively safe procedure, but it does carry with it some risks. There is a very small possibility of cutting or puncturing my intestines or other organs (including reproductive organs), which might result in serious bleeding or interference with the functioning of the organs. Allergy to any of the medicines used is also a remote possiblity. Infections may occur with any form of surgery, although there are seldom serious infections with endoscopy. I further understand that it will be necessary to give me a general anesthetic during the endoscopic examination.

I have been informed that if it becomes necessary to do abdominal surgery there are increased risks, including additional pain after surgery and a period of hospitalization and rest. The risk of infection is increased. Other risks include damage to the stomach, intestines or other organs, ruptures in the surgical wound or breathing muscles (diaphragm), burns on the skin, damage to the kidney and urinary systems, blood clots in the pelvis and lungs, and allergic reactions. These reactions are rare, although there is a very small risk of a serious complication causing permanent disability or death.

Alternatives. Pelviscopic surgery is relatively new in the United States, although it has been used for many years in Europe. An alternative to the pelviscopic surgery is major abdominal surgery, but that is not recommended because it may be unnecessarily risky and painful until after the endoscopic examination has been performed.

[*If there are other diagnostic procedures discuss those possibilities here.*]

I also understand that if it is determined that open abdominal surgery is necessary, it might be possible for the doctors to not perform it immediately but to wait a short time until I have discussed this matter further with them. Because of the additional difficulties and risks, I have decided against this delay.

I understand that refusing this procedure might be risky to my health or life. Because the doctors will not know what, if anything, is wrong with me without this procedure, it would be risky not to undergo this surgery the doctors are recommending. [*If the patient refuses the procedure, it would be important to describe the risks in some detail.*]

[*See note below concerning research and teaching.*]

Consent. Having been informed of the above and having discussed this operation with my doctor, I consent to Dr. ____________________ and such assistants as she/he may designate performing the endoscopic surgical procedures and, if necessary, the abdominal surgery (laparotomy) and removing (and disposing of) any tissue or organs that may be necessary or medically desirable. This consent extends to the administration of such anesthetics and medicines as may be desirable. I also authorize the doctors to perform such other procedures as they may determine are medically desirable or necessary during the course of this operation. I understand that the doctors cannot guarantee the success of this treatment.

I have had all of my questions answered to my satisfaction. I acknowledge receiving a copy of this consent form.

Signed by patient (and where appropriate, a guardian or member of the family), the physician, and at least one witness (a real witness who actually saw it signed).

Note concerning research and teaching. If anything other than standard, commonly accepted practice is undertaken (including research), additional information *must* be given and special consent *must* be obtained. If the patient will be used as a significant part of a teaching exercise, special consent should be obtained. These possibilities are discussed below.

Liability and Informed Consent

The failure to obtain informed consent may result in civil liability (malpractice). Negligence is usually the tort resulting from the absence of informed consent, although battery is a remote possibility.

Although informed consent liability occurs, the problems it causes have been overstated because it is not as common as one might expect.[48] A number of states have applied technical legal doctrines in a way that reduces the potential for informed consent liability.[49] For example, in requiring that a patient demonstrate a causal relation between the absence of informed consent and the injury, the patient may have to demonstrate both that she (or, in some states, a reasonable patient) would have refused the diagnosis or treatment if given informed consent and that she was not informed of the very risk of harm that in fact occurred.[50]

Informed consent liability tends to be found in cases in which there are factors that aggravate the absence of informed consent, as where there appears to be malpractice or where grossly inadequate information was given to the patient.[21] The absence of informed consent is often raised in malpractice suits as an alternative theory of recovery (i.e., in addition to a claim of bad medical care), but it is not often successful when the overall quality of care has been good, standard treatment has been provided, and the physician has been open and honest with the patient and her family.

Malpractice Liability

Civil liability, or malpractice, may arise out of the improper application of gynecologic endoscopy procedures.[51] Most commonly these cases are associated with the tort of negligence (a civil action based on the absence of reasonable care), although in rare instances liability may be based on an intentional tort (e.g., battery or intentional infliction of emotional distress) or on a contract (a physician guaranteeing a cure or good result). In this section, we consider the fundamentals of negligence liability and offer some suggestions for avoiding malpractice liability.

Purpose of Negligence

In any undertaking there will be some injuries: Automobiles will be involved in accidents, and some patients will be harmed by medical care. When these bad events occur there will be harm to someone in terms of damage to property or person (e.g., lost wages, pain, and medical bills). Society must determine who will pay for the losses when they occur. It is not a question of *whether* someone should bear these losses; they have occurred, and someone *will* bear them. Rather, the question is *who* should bear them. One possibility is that losses should be borne by those who are injured. One difficulty with that approach is that it may place an extraordinarily difficult burden on those who are unfortunate enough to be injured. Of course, this burden may be reduced if the person injured has paid for insurance to avoid the devastation of injury or if the government provides some form of reimbursement.

For the most part this approach is the one taken by our society; those who experience bad events or injuries are expected to bear the burden of the loss. Exceptions to this rule occur when injuries are caused by someone else's carelessness (negligence) or someone intentionally harms someone else. (As we shall see later in this chapter, special liability may also be imposed for harm resulting from defective products.) Thus, negligence shifts the economic burden of someone's carelessness from the person who was harmed to the person whose carelessness caused the harm.

The primary purpose of negligence liability is to compensate someone harmed through someone else's negligence. A second purpose is to provide an economic deterrent to carelessness.[52] The theory is that our concern for having to pay for the injury of others will make us somewhat more careful to avoid injuring them. Of course, there are some problems with this system. It is somewhat inefficient in that it requires that two often difficult questions be answered: Did someone's negligence cause an injury; and if so, what were the damages caused by the injury? In addition, it is not a very effective system of compensation in that many injured parties never recover anything and others recover too much.[53]

Principles of Negligence

Negligence liability requires four elements: existence of a duty, breach of that duty, injury to someone, and a causal link between the negligence and the injury. The failure of any one of these elements prevents liability.

It is generally said that there is a broad duty of care, a responsibility to act reasonably under the circumstances to avoid injuries. Negligence is simply the failure to act reasonably under the circumstances. Defining what "acting reasonably" (reasonable care) is under a specific set of circumstances can be difficult, however. It requires that we set a standard of care against which the conduct of the actor may be judged.

Defining the Standard of Care

Put most simply, a person is required to act as a reasonably prudent person would under the circumstances. This general obligation is refined for professionals. A physician is expected to act as a reasonably prudent physician would act under the circumstances. The failure of a practitioner to exercise the degree of care that a reasonably careful professional with similar training and expertise would exercise is negligence. This principle is carried one step further for specialists who are expected to provide a level of care consistent with that provided by a reasonably careful specialist.

The level of care required is not one of perfection. Not every mistake is negligence. A mistake is negligence only if it is an error that a reasonably careful practitioner (or specialist) would not have made under the circumstances.[54] Negligence focuses on a single incident rather than the general competence or reputation of a practitioner. Just as an outstanding driver may infrequently be negligent by missing a stop sign, an outstanding physician may be negligent in providing a particular medical service. Finally, note that the level of care that is expected is defined to include the circumstances under which it is given. The law takes into account circumstances such as emergency conditions in determining what a reasonable person would do. In short, malpractice is based on actions that would be considered by the profession itself to be bad practice.[55]

In any circumstance there may be more than a single reasonable kind of care to give. The law of negligence recognizes this fact. It also provides that the reasonableness of care should be judged in terms of the "school of thought" to which the practitioner subscribes. Where there are reasonable alternative methods of treating a condition, the physician may choose from among those approaches or schools of thought in providing care. At some point a whole school of thought may become negligent (e.g., a school of thought that favored treating appendicitis with aspirin), but that usually occurs when a school of thought has been discredited by a profession.

The level of care expected of someone increases as he or she becomes more expert (or in any way claims to be more expert) through special training or experience. Thus, a specialist is expected to have a greater expertise in the area of specialty and is expected to maintain a bit higher level of practice in the area of specialty.[56]

Those representing themselves ("holding themselves out") as specialists or as being particularly competent in an area will be held to that high standard that they imply or claim to have. Therefore, those claiming special expertise in gynecologic care will be held to a high standard of care, regardless of whether they have the training to justify the higher standard of care.

In some instances, a practitioner performing certain procedures is treated as though he or she were specially trained in that area of practice because it is negligent to undertake this procedure without specialty training, because it was negligent not to refer the patient to another physician, or because the physician has in effect held him- or herself out as being proficient in the procedure. This principle has special relevance in pelviscopic surgery and laser laparoscopy because it is likely that any practitioner performing those procedures would be held to a standard of care of someone adequately trained and proficient in them.

Establishing the Standard of Care

Determining whether a practitioner's care was within the standard required is most often determined on the basis of "custom" or the common practice. (At one time this care was defined in terms of the community in which the physician practiced. This "locality rule" has now been rejected in most areas and is virtually uniformly rejected for specialists.) In addition to custom, courts may rely on formal standards in determining what a standard of care is. For example, standards of good practice adopted by a specialty board or by a hospital may be used to help define good practice. In rare cases courts have decided that customary practice or adopted standards are themselves negligent. In the most notable case of this sort, a court determined that it was negligent for ophthalmologists not to perform glaucoma tests on those under 40 years of age.[57] Another, perhaps more common example is in the area of informed consent. If the custom were to inadequately inform patients of alternatives to treatment, that custom would not define an acceptable standard of care regarding informed consent.[58]

Because determining whether care was negligent most often requires a knowledge of the custom of practice, expert witnesses are called to give opinions about the quality of care and the custom of practice. The question for these physicians is not whether they would have given the care and not whether it was the best care possible. Rather, it is what the custom or practice was at the time of treatment and whether what the physician did was within the range of what a reasonably prudent practitioner (specialist) would have done under the circumstances.

It is important for the practitioner and the expert witness to remember that not all medical mistakes result in liability. Liability requires the coincidence of (1) a mistake sufficiently outside good practice to be unreasonable, (2) an injury to the patient, and (3) a causal link between the injury and the negligence.[59] It is also important to remember that liability is determined *post hoc*, that is, after everyone knows that an injury resulted from the provision of treatment. There is a natural tendency to see an action (or decision) as unreasonable when it has resulted in an injury.

Expectations play an important role here too. Where the expectation is that a procedure is completely safe, anything that goes wrong looks like it was caused by someone's carelessness. This fact may be part of the reason for the number of obstetric malpractice claims: People have come to expect perfect babies. The principle also applies to gynecologic endoscopy. Patients should not be reassured to the point that they believe there are no risks involved with the procedure.

Common Areas of Negligence

Negligence may arise out of a number of acts or failures to act. Major sources of negligence are the following.

1. Failure to conduct adequate examinations and tests
2. Careless execution of medical and surgical procedures
3. Inappropriate prescription or administration of drugs
4. Inadequate monitoring of the patient
5. Failure to refer patients to other specialists as needed
6. Unethical conduct that harms a patient

Avoiding Malpractice Claims

Although there are no guarantees that any practitioner can avoid malpractice claims, there are several ways to reduce the risk of malpractice.[51]

1. The most important factor, of course, is to engage in good quality, careful medical practice. You should adhere to the highest professional standards. Very good practice will infrequently result in malpractice claims. Most malpractice recovery results from practice that the profession itself would not be willing to label as good, solid care. Most of the following suggestions for avoiding malpractice are other ways of saying, "engaged in good medical practice."

2. Be sure that you are adequately trained before undertaking a diagnostic procedure or treatment. In the areas of pelviscopic surgery and laser laparoscopy it will require formal training.[60] Be careful not to claim (directly or indirectly) training or qualifications that you do not have; do not "hold yourself out" as being an expert in an area in which you do not have adequate training or experience.

3. Refer a patient to other physicians for care or consultation if the care she requires is not within your area of expertise. Of course, the desire of the treating physician to develop experience with the kind of case

presented by the patient, or to "keep" the patient for financial reasons cannot be the basis for a legitimate failure to refer.[62]

4. Maintain the currency of knowledge in your areas of practice. This point is especially important in pelviscopic surgery and laser laparoscopy where knowledge is advancing rapidly. Establish mechanisms to ensure that you stay current of the changes in practice.

5. Be sure that the facility in which care is given is adequately equipped to provide good emergency care if an unanticipated bad event occurs during treatment. Feel confident in the level of training of the staff at the facility.[14] If you select personnel for your office (or staff members elsewhere), do so with care, because you will probably be responsible for their negligence.

6. Use great caution in undertaking "nonstandard" treatments, that is, treatments not generally accepted and used by the rest of the medical community.[62] These treatments should be undertaken only after a particularly full informed consent and only with a clear protocol (preferably written) justifying the deviation from standard practice.[63] It is desirable that the protocol be reviewed by others, such as an Institutional Review Board (IRB).[64]

7. Obtain adequate informed consent as described earlier. Informed consent should be obtained for procedures that are physically invasive, of course.[65] Moreover, at least in an informal way, it should also be obtained for use of prescription drugs.[66]

The above suggestions for avoiding malpractice are directed toward providing good quality medical services. They help avoid engaging in professional negligence. The following do not reduce the possibility of negligence, but they may reduce the odds that a liability claim will be made if negligence occurs. Only a small proportion of negligent treatment results in legal claims. These suggestions, then, are for avoiding malpractice *claims* (or for dealing with them if filed), rather than avoiding malpractice.

8. Avoid unrealistic expectations by the patient and her family. The unrealistic expectations may not arise from anything you have told the patient but may come from friends, television, or *The Reader's Digest*, for example. Unrealistic expectations will suggest that someone is at fault if anything goes wrong. The informed consent process can profitably be used as a way of developing realistic expectations about the diagnostic procedure or treatment.[27]

9. Maintain good communications with patients.[67] Keep them informed. Let them know what to expect in terms of their conditions and their treatments. Except for good medical reasons, do not avoid delivering news, even if it is bad. If something does not go as expected, explain the problem and describe what can be done next.[51] There is considerable debate about whether a physician should tell a patient when the physician has made an error. There is much to be said for being open with patients about error, without saying that the error was careless. Others, especially some insurance companies, oppose this form of openness that admits mistakes. In any case, communicate to patients the fact that you care about them.

10. Maintain good records. The records should be as complete an account as possible in explaining *why* you did something (or did not do it), as well as *what* you did. Be aware that others may read these files and do not put confessions of negligence in them. Under no circumstances try to alter records to erase or avoid embarrassing information. This alteration is likely to be discovered and will make you look dishonest.[68]

11. When something goes wrong, contact your insurance company immediately. Your insurance contract probably requires that you notify the company of possible claims.

12. When something goes wrong, discuss the course of action with your insurance company and others involved (such as the hospital) to determine what should be done regarding the patient. Issues will include what to tell the patient and whether to charge the patient for the treatment, and

later whether to offer a settlement. I believe that it is best to be relatively straightforward and not to charge the patient. Although it is true that in some cases this tack may give the patient information that could be used against you, it also is likely to reduce the chance that a claim will be filed.

Hospital Practice

Hospitals have taken on new roles in ensuring the quality of health care in recent years. ("Hospitals" is used here very broadly to refer to the wide range of facilities in which health care may be provided.) Hospital accreditation rules, state regulations, and legal liability principles have imposed greater obligations on hospitals.[69] It is important that hospitals take seriously these obligations in gynecologic endoscopy in terms of the qualifications of those practicing, staff qualifications and training, and equipment acquisition and maintenance.[70]

Qualifications

Hospitals have an obligation to ensure that practitioners who undertake complicated diagnosis and treatment within the institution are qualified to do so.[71] The process of granting hospital privileges to practitioners is an important part of this limitation on practice.

Only those who can demonstrate adequate, formal training should be permitted to schedule and undertake pelviscopic surgery and laser laparoscopy. It is important that hospitals use any formally adopted standards for determining what training is adequate. They should also determine that their grant of privileges to practitioners is sufficiently specific to limit practice to those areas in which the physician is adequately trained. Carelessness in the process of granting privileges to a practitioner who turns out to be negligent may result in liability for the hospital.

Hospitals also have a responsibility to review continuously the work of practitioners to ensure that they are staying competent with new technology and knowledge. The usual range of hospital committees and peer review mechanisms should be adequate for this process if those reviews are meaningful in terms of quality and if they are used to make changes in staff privileges when it appears that a member of the staff is no longer at a reasonably high level of competence in some areas. In fact, privilege adjustments (removing authority to undertake some procedures) is probably the "weak link" in hospital privilege qualification reviews. The competition for patients, the economic pressures caused by Diagnosis Related Groups (DRGs) and the like, and the closer ties between physicians and hospitals occasioned by delivery systems such as Preferred Provider Organizations (PPOs) may make it more difficult for hospitals to impose these practice limits on otherwise good practitioners.[72] Nevertheless, the hospital that does not undertake these privilege adjustments is inviting liability for this failure.

In addition, hospitals should determine that practitioners are practicing only within the limits of their privileges and competence. Those who are not privileged to do pelviscopic surgery or laser laparoscopy must not be permitted to perform these procedures.[60] Hospitals should not permit physicians without appropriate staff privileges to schedule those procedures. In addition, nurses and other professionals who see unauthorized practices occurring should report them to supervisors or otherwise try to stop them.[73]

Hospital Support Staff

Hospitals have an obligation to use reasonable care in the selection of nursing and support staff. It includes ensuring that those working in sophisticated areas of gynecologic endoscopy are adequately trained.[74] The legal responsibility for employees (whether of the hospital or of the physician) extends beyond care in selection. The concept of *respondeat superior* or vicarious liability means that an employer (principal) is responsible for the negligence of his or her employees (agents). Therefore, a hospital may be liable for the negligence of nurses and other employees.[52]

Principal/agent relationships are extremely complicated in medicine, involving as they do the concepts of shifting agency (a division of responsibility between hospitals and physicians for the negligence of nurses and others) and ostensible or apparent agency (treating someone as an agent for liability purposes). This subject is well beyond the scope of this chapter. However, it should be clear that great care is called for in supervising professional staff assistants.

Equipment

Hospitals have considerable responsibility for the equipment they purchase and maintain for pelviscopic surgery and laser laparoscopy.[75] In the next section we will review the issue of equipment failure, but a hospital should be aware that it has a particularly strong obligation to provide medical equipment that is not defective and thereby harmful or unnecessarily dangerous.

Records

Like physicians, institutions should be careful that complete and accurate records are kept. Most accredited hospitals now have reasonably good mechanisms for recordkeeping. Other institutions may need to review their systems to be sure that their records are adequate. All should continue efforts to complete patient records without significant delays. In addition, all institutions should have mechanisms to ensure that records are not altered. There should be some process for protecting a record's integrity, particularly when it may become the subject of litigation or dispute.[68]

Equipment

The federal Food and Drug Administration's (FDA) regulation of medical equipment,[76] and the liability associated with the equipment are complicated matters that could (and do) fill volumes. In this section we will only briefly touch on some of the liability issues associated with equipment failure.[77] It is an area in which there is rather considerable disagreement about what the law is and should be.[78] Liability (as opposed to FDA regulations) is an area that state law generally controls. Therefore, there is diversity in the way states handle it.

The principles discussed in this chapter suggest that the careless design, manufacture, or maintenance of equipment could give rise to negligence liability—and so they can. A high degree of care is expected of those who provide medical equipment because they know that any defects are likely to do serious harm to patients. It requires care not only by the manufacturer of the equipment but also by those who maintain and use it. For example, a hospital is expected to be concerned about the way it sterilizes and cares for its equipment. Both the hospital and the physician using the hospital may be expected to perform reasonable inspections of equipment to determine that it is in good working order.[75]

The potential for liability for defective equipment may extend beyond negligence. After World War II courts started expanding liability for harm caused by defective products. They now will impose "strict liability" for products that are defective and cause injury.[79] The difference between negligence liability and strict liability is that in negligence a plaintiff must prove that a defect in the product resulted from someone's carelessness, whereas in strict liability she must prove only that a defect existed and caused injury. As you can imagine, "defective" in this context takes on a somewhat special and technical meaning. Among the reasons for imposing this strict liability are to spread the costs of injuries among those who benefit from using the product, to make product manufacturers and distributors as careful as possible, and to have the prices of products reflect their true costs (including the costs of injuries). Strict liability is generally *not* applied to *services* such as medical care, but it may be applied to *products* used in medical care.

A product defect may result from an error in manufacturing or packaging (or perhaps maintenance), from an error in designing the product, or from defective labeling (notably a failure to give adequate warnings or instructions concerning the product). Determining what is a "defect" has caused some difficulty, and defining a "design defect" has been particularly troublesome.[52] Of course, the fact that someone was injured by a product is not sufficient to prove that the product was defective in a legal sense.

In the area of medical equipment, there is also debate about whether the use of the equipment is the use of a product or the provision of a service (services are not subject to strict liability), and if strict liability should be applied at all to medical equipment and devices. In addition, when equipment is produced by the manufacturer, purchased and maintained by a hospital, and used by a variety of physicians, it may be exceedingly difficult to determine who is responsible for the defect or for the injury.[80]

From the current law some gross generalizations can be made. Where strict liability is imposed for medical devices or equipment, as a practical matter the manufacturer is usually responsible for any defect in design or manufacture, or for a failure to label or warn. The hospital is responsible for failing to pass on to the physician any warning and for defects caused by its mistreatment of the product. Physicians are usually not part of the chain of distribution through which strict liability is passed. However, physicians may be negligent for not selecting the proper instrument or equipment, for misusing it, or for failing to inspect it; this liability usually results in negligence rather than strict liability.[81]

Other Legal Issues

Physicians practicing in the areas of pelviscopic surgery and laser laparoscopy are likely to face several other important legal issues.[47] In this section, examples are given of the range of legal concerns that may be encountered.

Confidentiality

Both physicians and patients probably overestimate the degree to which the confidentiality of information from treatment can be maintained.[82] A close study of the law of one state indicated that the exceptions to confidentiality (and to the related concept of testimonial privilege) essentially consumed the rule.[83] What protection of confidentiality the law has given with one hand, it has often removed with the other.[84] This fact suggests that gynecologists should be cautious in promising absolute confidentiality to information learned during treatment.[85]

Treating Minors

The traditional rule has been that parents must consent to treatment for their minor children.[86] This rule has now been modified somewhat by statute or court decision in many states. These modifications may permit a minor to consent to gynecologic or obstetric care for herself. These statutes commonly exclude permanent sterilization and abortion from the procedures to which the minor may consent.[38] The Supreme Court has recognized a constitutional right to privacy that includes the right of a "mature" minor to decide to have an abortion[87] or to use contraceptives even over the objections of her parents.[88] (A mature minor is one capable of understanding the nature and consequences of a decision to have an abortion.)[89]

The statutes allowing minors to consent to treatment may permit or require that their parents be notified of the treatment. A number of states have imposed parental notification obligations for minors seeking abortions or contraceptives. The Supreme Court will ultimately determine the extent to which states can go in requiring notification. Where such notification is required, the practitioner should inform the minor at the beginning of treatment of this reporting requirement.[90]

This area obviously is one in which the practitioner treating minors should watch closely for changes in the law. It is also an area in which those practicing may make a contribution to the public debate. The practical consequences of such laws are sometimes not recognized by courts and legislatures, and gynecologists and obstetricians may help provide this information.[41]

Patients as Research and Teaching Subjects

When patients are used as research subjects (e.g., in clinical trials of new drugs), special care must be exercised to ensure that they are protected from harm. Following the disclosure of Nazi atrocities committed in the name of research, attention was focused on the risks of experimentation.[91] Much human experimentation now is controlled by federal law, institutional regulations, or ethical principles.[92] Almost any experimentation undertaken should be first examined by some review body, such as an ethics committee or IRB. IRB approval is required by the federal government for government-funded studies and human trials of new drugs and devices.[93]

IRB and other review should ensure that the potential benefits of the study outweigh the potential risks, that there is adequate informed consent, and that the risks are as limited as possible. This review is intended to protect the patient, but indirectly it also helps protect the physician by avoiding unnecessary experimental risks.[94]

No experimental study should be undertaken by a physician without carefully checking to determine if any regulation is applicable and what review is legally required or desirable. IRB review generally takes several weeks and should be completed before a grant application is submitted. Physicians should therefore provide considerable "lead time" when asking for IRB review.

Patients who are used as "teaching subjects," unlike research subjects, are not commonly protected by federal and institutional regulations.[95] Nevertheless, practitioners should consider using the same principles that justify ethical experimentation: The benefits should outweigh the risks, there should be full informed consent (including the right to refuse to be a teaching or research subject), and the risks should be as low as possible. Too often these principles are not carefully followed. Patients may not be informed that they are teaching subjects, let alone consent to the involvement.[95]

A Note of Caution

A note of caution is in order about the legal principles discussed here. They may not fully describe the law in any given state for two reasons. First, most of the issues discussed are matters of state law, and the law varies somewhat from state to state. Although most states follow the same general principles of law, there are some important differences adopted by some states. For example, several states have modified malpractice principles by statute, and states also vary in their approaches to minors' consent to treatment.[38] Thus in any state there are exceptions or nuances to generally stated legal principles. A second reason for caution is the speed with which the law is changing. In general, the law related to medicine is in flux, particularly in areas affecting reproduction and new technology.

The variations in legal principles from state to state and the speed with which the law is changing in areas that affect gynecologic endoscopy mean that those practicing in this area of medicine should pay particular attention to the variations and changes affecting their own states. It may require that practitioners establish a continuing relationship with attorneys in their states. Certainly, institutions such as hospitals should have their policies and practices related to pelviscopic surgery and laser laparoscopy reviewed by an attorney competent in the area of health law. It is an area of the law where some early "preventive" activity can avoid some later legal problems.

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22 Economic Impact of Gynecologic Endoscopy

MICHAEL W. METHOD and LOUIS G. KEITH

Until the early 1980s, the cost of specific surgical procedures was of relatively small concern to health care providers. The implementation of Diagnostic Related Groups (DRGs) and other cost-containing governmental policies have made physicians increasingly aware of the economic impact of their therapeutic decisions. In gynecology, the selection of an optimal and cost-effective surgical procedure for a given disease process is slowly becoming an area of concern, especially when more than one method of treatment is available.

Many operations traditionally performed using full laparotomy can be accomplished using operative laparoscopy or what many would term "pelviscopic surgery." Examples include, but are not restricted to, salpingectomy for tubal disease (including ectopic pregnancy), oophorectomy for benign processes (including endometriosis), myomectomy, adhesiolysis, and tubal reconstructive surgeries. Details of these procedures are discussed elsewhere in this text (see Chaps. 9, 10, and 17). The aim of this chapter is to provide insight into the economic impact of laparoscopic procedures vis-à-vis laparotomy.

The opinions expressed are those of the author and do not reflect those of the United States Air Force or the Department of Defense.

Impact of Endoscopy in Gynecology

Direct Costs

From the time of its acceptance in the late 1960s and early 1970s, endoscopy has revolutionized gynecologic patient care in the United States. In the past, full laparotomy was required for tubal sterilization, diagnosis of obscure pain, and treatment of many other relatively minor gynecologic problems. Gynecologists often were reluctant to suggest laparotomy as an initial means of providing access to the pelvis for treatment of these conditions, as laparotomy was associated with a recognized risk—albeit small—of morbidity and mortality. In contrast, laparoscopy provided easy access to the female pelvis with acceptable morbidity and mortality.

The initial enthusiasm for laparoscopy was based in no small part on the fact that for the first time female sterilization was available at a reasonable cost and could be accomplished in vast numbers of cases. Subsequently, requests for sterilization became the most common indication for the use of laparoscopy. Since then, many other important laparoscopic operations have been described. Pelviscopic surgery and laser laparoscopy represent but a continuum of this therapeutic evolution.

The attainable objectives of modern laparoscopic surgery should include the following.

1. Reduction of operative time and morbidity
2. Reduction of total hospital stay
3. Reduction in recovery time (both at home and away from work)
4. Achievement of the same or better therapeutic effect compared with laparotomy
5. Reduction of potential surgical complications
6. Reduction of total direct cost to patient, hospital, and third party payers

The literature suggests that these objectives indeed can be attained, although to varying degrees for differing surgical indications.

As early as 1973, Shapiro and Adler[1] discussed the points noted above in a report on the excision of ectopic pregnancy with laparoscopy. Shortly thereafter, Yuzpe[2] extended the line of reasoning initiated by these authors and proposed the use of laparoscopy for aspiration of ovarian cysts, lysis of adhesions, and similar operations. Other authors rapidly concurred, but not until 1985 did Levine[3] attempt to quantitate comparative differences in costs between laparoscopic surgery and laparotomy. He studied three types of operations (lysis of adhesions and fulguration of endometrial implants; resection of ovaries, lysis of adhesions, and salpingectomy; salpingo-oophorectomy, oophorectomy, salpingostomy, and myomectomy) performed during the same period.[3] The following cost-related parameters were assessed.

1. Length of postoperative stay
2. Hospital room charges
3. Recovery room costs
4. Operating room charges
5. Laboratory charges
6. Anesthetic drugs
7. Miscellaneous medications
8. Medical supplies

In the aggregate, patients treated for similar conditions by laparoscopy achieved savings ranging from $1141 to $1498 compared with patients treated by laparotomy in this study.

Aside from Levine's report,[3] few cost analyses exist for therapeutic alternatives to laparotomy. Nonetheless, a variety of reports confirm that laparoscopy offers distinct treatment advantages over laparotomy for specific conditions, i.e., ectopic pregnancy. Since 1973, several authors have used the techniques described by Shapiro and Adler[1] for laparoscopic treatment of ectopic gestation, especially in France.[4–8] In the United States, Reich et al.[9] analyzed a small series of cases treated between 1982 and 1986, noting that the average operating time of 70 minutes for a laparoscopic linear salpingostomy was no longer than the operating time required with laparotomy for tubal preservation. Reich et al.[9] additionally reported the operating time for complete salpingectomy as being less than 60 minutes. Perhaps more importantly, the average hospitalization of 1.06 days in this series was far less than that of 5.2 days required for conventional treatment by laparotomy. Bornstein et al.[10] also discussed reduction in hospital and recuperation time among 22 patients who had laparoscopic treatment of an ectopic pregnancy. In this series, the average hospital stay was less than 24 hours, average blood loss was less than 5 ml, and all patients returned to full activity within 3 weeks of surgery. No febrile morbidity followed surgery, and no patients were required to return to the operating room for bleeding or other complications.

Semm and Mettler described a full range of laparoscopic operations included under the term pelviscopic surgery.[11–13] In general, these operations were designed to replace laparotomy for standard gynecologic indications. Initial acceptance of these procedures was slow, especially in the United States. More recently, however, the efficacy and safety of these techniques have been reported by skilled American surgeons, and Semm and his colleagues have conducted extensive demonstrations of pelviscopic surgical techniques. It is presently reasonable for a well-trained and experienced laparoscopic surgeon to offer patients the benefit of reduced operating time and morbidity for a wide range of procedures once thought to exclusively require laparotomy.

Although comparative randomized trials have not yet been performed to assess the efficacy of laparoscopy for all purported indications, numerous publications attest to their basic safety and their capability of reduced length of hospital stay.[3,6,9,14,15] A case in point is the use of laser laparoscopy for the treatment of endometriosis.[16,17] Diamond et al.[16] have demonstrated marked improvement when laser laparoscopy is used in conjunction with medical therapy in the treatment of advanced stage endometriosis. Others[17] advocated the use of laser laparoscopy rather than conventional laparoscopy or laparotomy for the treatment of endometriosis. Randomized trials may be necessary, however, to determine if this form of therapy is more efficacious with regard to fertility. For accurate assessment of this modality vis-à-vis laparotomy, future studies will need to compare conventional laparotomy, laser laparoscopy, and, in some instances, medical therapy. Cost data on laser laparoscopy compared with laparotomy are presented in a later section in this chapter.

Costs: Hidden and Otherwise

Thus far, we have mentioned only obvious costs, i.e., those related to the total hospital stay and the type of surgery performed. Just as there are indirect patient costs associated with any operation (time away from work, home, etc.), medical care providers have indirect or hidden costs that rarely are considered in selecting a specific therapeutic operative approach (Fig. 22-1). The following comments pertain to these hidden costs.

Medical Equipment Life Cycle Costs

The equipment chosen to perform any operation not only requires an initial expense for purchase but is associated with recurring expenditures for routine maintenance.[18] Medical equipment costs typically include four major categories of expenditure: (1) acquisition costs; (2) initial start-up costs; (3) costs of operation and support (as high as ten times purchase costs); and (4) disposal costs. The last three categories generally are overlooked in the initial selection process.

Figure 22-2 pertains to equipment availability and serviceability over time. Such

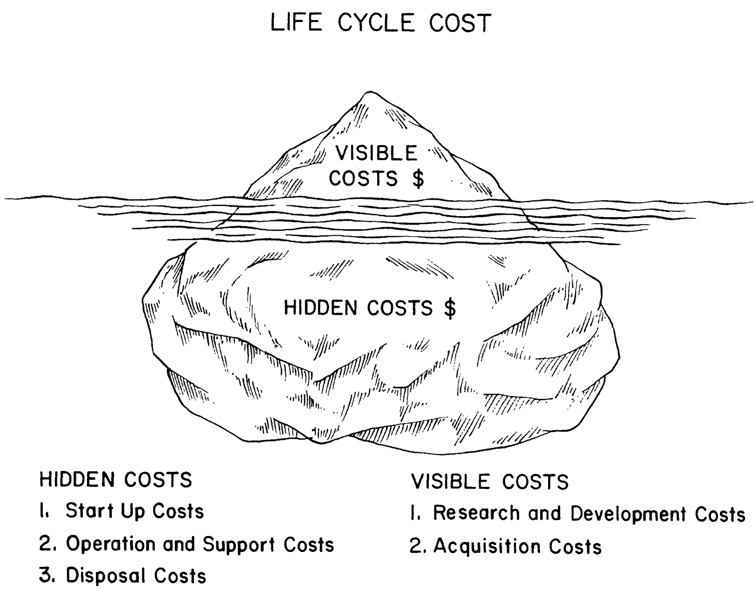

FIGURE 22-1. Total (life cycle) cost of ownership. (Reprinted from ref. 18, with permission of The Journal of Reproductive Medicine.)

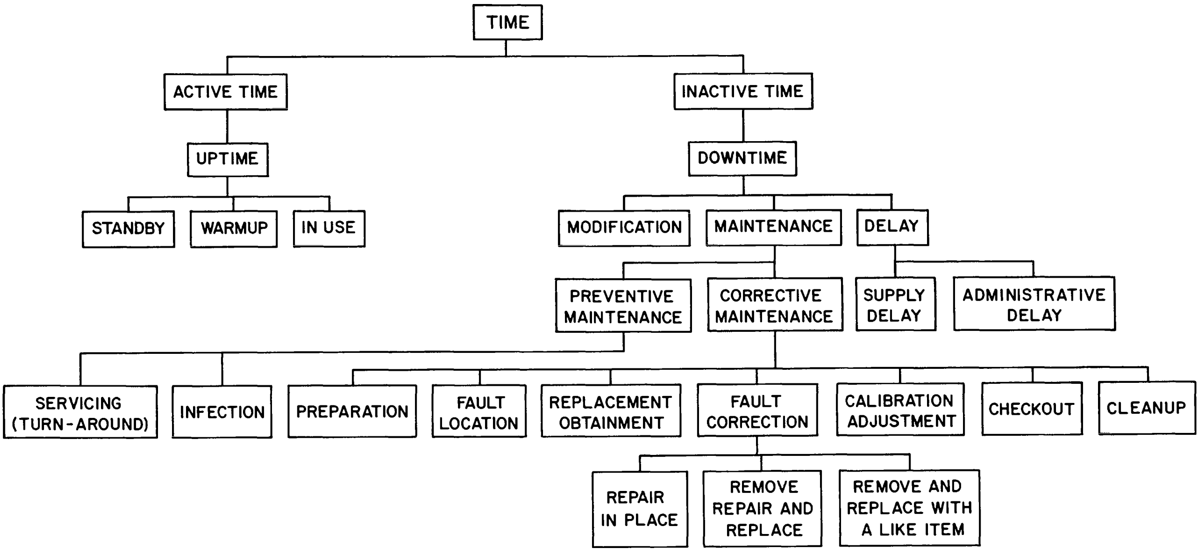

FIGURE 22-2. Equipment availability and serviceability related to time. (Reprinted from ref. 18, with permission of The Journal of Reproductive Medicine.)

schemes should be considered for the purchase and maintenance of laparoscopic equipment in general and for lasers in particular. Over time, initial equipment costs clearly may be superceded by excessive operating and support costs.

Cost Versus Treatment Complexity

An interesting model for determining real cost is the treatment complexity model described by Gladen et al.[19] In this system, initial costs of antibiotics were considered first-order costs, use costs as second-order costs, follow-up as third-order costs, and adverse reactions as fourth-order costs. According to this type of model (and assuming the patient is admitted the morning of surgery) any reasonable cost incurred on the day of surgery is a first-order cost. Higher-order costs would then relate to the need to provide a hotel, restaurant, laundry, and full service staff for any hospital days after the initial day. Thus, if the patient is discharged the same day, associated second-order costs need not be incurred, although expenditures for follow-up and adverse reactions may still be required.

Cost of Complications

Complications, whatever their nature, increase the cost of a surgical procedure by prolonging hospital stay and generating a need for additional medical resources. This statement holds true for complications as simple as urinary tract infection or as complex as evisceration. Although the need for anesthesia remains an important source of complications regardless of the type of operation performed, the nature of anesthetic complications varies considerably with the skill of the personnel administering anesthesia as well as the length of the surgery. In general, the duration of the surgical procedure is correlated with the incidence and type of complication. Of equal importance, the size (and direction) of the abdominal incision has been correlated with recuperation times. It has long been recognized that patients confined to bed for any appreciable length of time as a result of pain from a large abdominal incision are at risk for at least two major complications: pneumonia and thrombophlebitis. The emergence and subsequent popularity of the minilaparotomy incision in gynecology was related directly to a desire to have the patient return to full activities as soon as possible. The nature of laparoscopy eliminates many of these concerns, even if the patient has had multiple abdominal punctures and extensive intraabdominal surgery.[3,9,11–13]

Caveat Emptor

Since the introduction of DRGs, the reduction in health care costs has become a matter of public concern. To date, the thrust of cost containment appears to rest on the gradual elimination of presumably useless care.[20] In some instances, physicians have unwillingly transferred their traditional decision-making authority to third party payers, and these actions have resulted in intense criticism by patients and other interested individuals.

In the case of pelviscopic surgery, the possibility of its broader application implies that the number of laparotomies performed in our specialty may decline by some as yet unknown factor in the next decade. Rather than adopting a congratulatory posture for such a change and the potential savings that may result from it, at least one analyst[20] believes that all such efforts are limited unless restrictions are placed on technologic innovation or beneficial services rationed. According to Schwartz,[20] three important variables account for increasing hospital costs despite intensive cost-containment efforts: (1) population growth; (2) increased hospital operating expenses due to inflation, escalating supply costs, and the need to maintain a constantly available pool of highly skilled workers; and (3) increased use of services based on the diffusion of technologic advances into the community. Whereas factors 1 and 2 are not amenable to local control, factor 3 will become a major point of contention in the future as more and more hospital administrators and physicians look closely at their ability to amortize capital outlays fully rather than assume this debt as a necessary operating expense.

The decision to provide operative laparoscopy as opposed to laparotomy is illustrative of this process. In 1986, the budget request to upgrade existing laparoscopy equipment to pelviscopic standards at David Grant Medical Center (Travis AFB, Vacaville, CA) was more than $30,000 at governmental prices. At Northwestern Memorial Hospital (Chicago, IL) all laparoscopy equipment was replaced and upgraded in 1984 at a cost of $36,329. These expenditures do not imply that either institution was unable to provide current standards of care before the requested improvements. Rather, these outlays represented management decisions to upgrade facilities to "state of the art" levels so patients might have the benefit of the latest technologic advances in pelviscopic surgical techniques. It is conceivable that these institutions as well as others will further upgrade equipment in the future to include laparoscopic laser(s) and/or other technologic advances. If such investments are made in hopes of decreasing specific patient charges, they would fall in the category of expense that Schwartz[20] referred to as contributing to the overall increase in hospital expenditures. It is logical that the overall expenditures required to maintain "state of the art" technology will become an item of intense debate in the near future as advances continue.

Selected Economic Data

Operative Laparoscopy

Ectopic Pregnancy Model

The provision of safe and efficacious treatment for patients with ectopic pregnancy has become one of the principle concerns in gynecology. Between 1970 and 1980, a threefold increase in the prevalence rate for ectopic pregnancies was documented.[21] This trend continued during the 1980s and has been related to increases in the reported numbers of sexually transmitted diseases (especially gonorrhea and *Chlamydia* infection). It is presently estimated that prior upper genital tract infection represents the etiologic factor in more than 50% of all ectopic gestations.[22] Rubin, et al.[23] have reported the incidence of ectopic pregnancies to be nearly 1% of all pregnancies.

Whereas laparoscopy is widely accepted as an effective means for early diagnosis of tubal ectopic pregnancy, its use for definitive treatment is practiced only in scattered centers throughout the United States and Europe. Depending upon the status of the tube at the time of the surgery, salpingectomy or linear salpingostomy with removal of all pregnancy tissue at the time of laparotomy remains the standard treatment (see Chap. 5).

Two publications advocating laparoscopy for the treatment of ectopic pregnancy may be cited as typical. In 1980 Bruhat et al.[4] reported on 60 patients. In this series, there were three operative failures that resulted from incomplete removal of trophoblastic tissue. Eighteen of the 25 women in this series who later desired pregnancy did conceive. Seven years later, Reich et al[9] reported 17 tubal pregnancies successfully treated with a laparoscopic procedure. Several pelviscopic surgical techniques were used including total salpingectomy, partial salpingectomy, fimbrial expression, and salpingostomy. Four of the six patients in this small series who later tried to conceive were able to have intrauterine pregnancies. Although we are unaware of controlled, randomized trials documenting equal or greater efficacy for laparoscopy compared with laparotomy for the treatment of tubal ectopic pregnancy, the increasing utilization of operative laparoscopy as an alternative to standard abdominal procedures may make this question more an academic exercise than a practical trial.

TABLE 22-1. Laparoscopy versus laparotomy

Procedure	Hospital charges*	Length of stay* (days)
Laparoscopy (N = 22)	$2321 (560)	1.3 (0.65)
Laparotomy (N = 32)	$3772 (314)	3.7 (1.3)

* Numbers in parentheses are standard deviations.

Direct Costs

Data from Method (unpublished data: Method M, Keith L, Reich H) clearly demonstrated the economic advantage of laparoscopic treatment of tubal ectopic pregnancies when compared with laparotomy in a small series of patients. From January 1983 through December 1986, there were 22 patients who underwent laparoscopic diagnosis and treatment for their tubal pregnancies. The mean hospital charges were calculated at $2321 and the length of stay (LOS) at 1.3 days (Table 22-1). During this time at the same treatment facility, 32 patients underwent laparotomy for tubal pregnancy. Hospital charges averaged $1451 more for laparotomy patients, with the LOS stay extending 2.4 days longer than for patients who underwent laparoscopic surgery. Based upon estimates from the Hospital Discharge Survey in 1984, approximately 52,000 ectopic pregnancies occur annually.[22] Assuming that only one-half of these patients could be successfully treated by laparoscopy and using the cost differential cited here, the total annual savings would exceed $37 million if laparotomy was replaced by laparoscopic surgery in these cases.

Others have had comparable experiences. For example, Goodman et al.[24] cited data obtained from seven experienced operative laparoscopists at university hospitals and community institutions. The outcome differences comparing LOS and costs of pelviscopic surgery and laparotomy were significantly different (Table 22-2). Of interest, operating times were similar and fertility

TABLE 22-2. Days in hospital and hospital charges

Operation type	Pelviscopic surgery (N = 165)	Laparotomy (N = 83)
Days in hospital		
Oophorectomy/salpingo-oophorectomy	1.7	5.0
Salpingectomy/salpingotomy	1.15	4.0
Cystectomy/endometriosis	1.1	4.8
Hospital charges		
Oophorectomy/salpingo-oophorectomy	$2115	$4310
Salpingectomy/salpingotomy	$2225	$4210
Cystectomy/endometriosis	$3078	$5108

rates after laparoscopy were equal to those obtained after laparotomy.

Indirect Costs

Indirect costs increase significantly once the abdominal cavity is violated by any laparotomy incision. Washington et al.[25] have estimated that disability from diagnosis and treatment of tubal ectopic pregnancy by laparotomy extends for 28 days and results in $134 million of lost wages and lost value of household management time. To date, similar estimates are not available for laparoscopic management of ectopic pregnancies, but most published reports indicate complete recovery in less than 2 weeks (less than one-half the time estimated for a laparotomy). In the final analysis, these indirect cost benefits may exceed direct cost benefits and be the true economic contribution in support of the use of laparoscopic techniques for the diagnosis and management of tubal pregnancies, as these savings are not diminished by additional training and equipment costs and can accrue regularly thereafter.

Laser Laparoscopy

The development of laser laparoscopy as a safe, accurate, and effective operative technique may revolutionize laparoscopy and, in turn, gynecology. At present, several types of laser are commonly available, each possessing unique physical and operating characteristics. The CO_2 laser is most widely used for surgical procedures; it acts by vaporization of tissue and is most effective in cutting (see Chap. 15). In contrast, the KTP and Nd:YAG lasers are most effective for coagulation. The argon laser combines the benefits of cutting and coagulation and has been promoted for use in laparoscopic neosalpingostomy, fimbrioplasty, adhesiolysis, and transection of the uterosacral ligaments for pelvic pain. Because each type of laser is unique with regard to tissue penetration, thermal injury and operative safety, equipment must be carefully chosen to achieve the desired tissue effect (see Chap. 16). For example, the CO_2 laser has been successfully used to excise endometriotic implants.[26]

Daniell and Herbert[27] documented a 75% tubal patency rate in 22 patients treated by salpingostomy with laser laparoscopy for repair of a hydrosalpinx. Their subsequent pregnancy rate compares favorably with the results of classic tubal surgery via laparotomy and suggests that CO_2 laser laparoscopy may be equally effective and generate savings to the hospital and third party payers, necessitate less time off from work (indirect cost reduction), and provide significant decreases in patient discomfort.

The use of laser laparoscopy in conjunction with danazol therapy in the management of advanced stage endometriosis has been associated with reversal of infertility and relatively constant and significant success rates.[26–31] Of particular interest is the shorter period of time (and cost) required for adjunct therapy compared with danazol treatment alone. Some authors consider CO_2 laser laparoscopy an alternative to the medical treatment of stages I and II endometriosis (see AFS Classification, Fig. 17-1).[15] In one study of 158 patients, operative time for the treatment of endometriosis and adhesiolysis by laser laparoscopy averaged 110 minutes, which was comparable to that during laparotomy for the same procedures.[14] In this report, pregnancy rates and pain relief were equivalent or better than those reported by patients treated via laparotomy. Therefore, the CO_2 laser may offer immediate, complete, low risk, and inexpensive treatment for endometriosis.

Direct Costs

Data provided by Dr. Camran Nezhat from the Fertility and Endocrinology Center (Atlanta, GA) demonstrate clear cost savings in the treatment of endometriosis. At present, videolaseroscopy and laser laparoscopy are used to treat mild to extensive endometriosis and extensive pelvic and peritubal adhesions. One hundred patients who underwent laser laparoscopy for extensive endometriosis were compared with 15 patients with similar disease who had laparotomy. The average charge for all patients who had laser laparoscopy was $1970 with the average length of stay 16 hours, in contrast to an average cost of $3435 and a length of stay of 5.8 days for the 15 patients who underwent laparotomy (Table 22-2).

Summary

Undoubtedly, the ability of patients to undergo desired operations on an outpatient basis underlies much of the initial enthusiasm for laparoscopy. Even so, the actual length of time in the hospital was not considered of critical economic importance until the early 1980s, and wide variations existed in total length of stay for many common and similar operations. For example, in the mid-1970s, patients undergoing sterilization or diagnostic laparoscopy at the Phoenix Surgi-Center (Phoenix, AZ) were discharged on the same day of operation (and admission). During this same period, a significant percentage of patients at Northwestern Memorial Hospital (Chicago, IL) were admitted the night prior to laparoscopy and discharged the day after surgery (and recovery from the heavy premedication given with anesthesia). In these cases, hospital charges alone at Northwestern exceeded total charges at the Surgi-Center, based solely on the difference in LOS. In recent years, however, the concept of day surgery (admission and discharge on the same day) has been strongly endorsed in traditional hospitals as well as "short stay" surgical facilities. In many instances, this change was mandated by third party payers who recognized that the quality of care was not inherently related to LOS.

The utilization of endoscopic surgical techniques has extended the concept of shortened hospital stay that was formerly used for diagnosis and sterilization to include more complex types of operation. Indeed, Semm[11–13] has suggested that up to 80% of all laparotomies can be replaced by pelviscopic surgery. In the analysis provided by Levine[3] and supported by others, the use of pelviscopic techniques can achieve cost savings of approximately one-half compared with the use of laparotomy to treat the same condition. Although the success of operative laparoscopy or pelviscopic surgery may depend to some degree on the user's experience, it is clear that many of the surgical conditions traditionally thought to require laparotomy can be effectively treated via laproscopy and pelviscopic surgery. Thus, the economic impact of the use of gynecologic endoscopy is great. The potential indeed exists to offer surgery that is both cost effective and efficacious. Widespread utilization of the procedures outlined in this text will alter the practice of gynecology.

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23 Clinical Perspectives and Credentialing

CARL J. LEVINSON

A major revolution in the performance of gynecologic surgery has occurred. The transformation has been complemented by a meteoric acceleration in technology and the need for surgical expertise. This expansion of surgical acumen is so significant that it ranks with the performance of the hallmark report of the first vaginal hysterectomy and the pioneering use of the endoscope in gynecology.[1] These surgical techniques are frequently termed "operative laparoscopy"; but as discussed in the Preface, it has been difficult for the medical community to come to a consensus as to terminology. Whether we use the term "advanced laparoscopic surgery", "operative endoscopy", or "pelviscopic surgery", the procedures are the same.

The scope of this endoscopic surgery ranges from resecting extensive adhesions to experimental laparoscopic hysterectomy and lymph node resection.[2] How we now perceive and manage gynecologic disorders was presaged by the work in the early 1970s, of Kurt Semm in Kiel, West Germany, and by Maurice Bruhat in Clermont-Ferrand, France. Their pioneering efforts have been modified and amplified, but the initial contributions are quite evident.

The evolution of current endoscopic surgery was driven by the development of new surgical instruments and techniques plus ultrasonography, laser use, and the Endoloop (Ethicon, Somerville, NJ); (also termed, the Roeder loop). Hemostasis was improved by extracorporeal and intracorporeal knot-tying techniques. Titanium and absorbable staples for endoscopy, soon to be marketed, will further enhance the endoscopic surgeon's capabilities.

Ultrasonography, computed tomography scan and magnetic resonance imaging represent noninvasive technologic improvements in that these diagnostic modalities provide enhanced preoperative and post-operative information.

Surgical Procedures

Although exclusively a diagnostic tool at that time, modern *hysteroscopy* was performed more than 20 years ago. Uterine cavity distention media (CO_2, high-molecular weight dextran, and Ringer's lactate solution) have fueled the progression of hysteroscopy. Technology has improved the operative capabilities of hysteroscopy so that resection of a uterine septum and endometrial ablation with hysteroscopic laser delivery are possible. Future applications may allow for routine evaluation of abnormal uterine bleeding, tubal lumen assessment, transcervical tubal sterilization and correction of cornual obstruction. Microcolpohysteroscopy is currently being evaluated.

The revolution in *advanced* laparoscopic surgery is ongoing. Thus, the time needed for perspective has not yet come. A large percentage of these surgical procedures are used to manage fertility problems, including some previously designated "microsurgery."

An incomplete list of procedures now amenable to endoscopic surgery would include: lysis of adhesions, fimbrioplasty, neosalpingostomy, conservative surgery for endometriosis, ectopic pregnancy resection, and ovarian surgery for benign disease. The progression from laparotomy to operative laparoscopy seems inevitable. In this author's personal experience, more than 50% of laparotomies performed 5 years ago are now done as laparoscopic procedures. At the centers headed by Bruhat[3] and Semm,[4] 50–75% of all gynecologic surgeries are performed in this manner, the percentage being higher for those related to infertility. Laparotomies have now been reserved for abdominal hysterectomies, most operative procedures involving cornual obstruction, and a very few cases that have been designated as "contraindicated" for laparoscopic approach. Even the sacrosanct tubal anastomosis is now being accomplished laparoscopically by some surgeons in Europe, partially because of the availability of fibrin glue (Wattiez A, Personal communication, 1988).

Instruments

Special instruments have been designed to enhance the efficacy of pelviscopic surgery. These instruments must be available at all times, as all technical procedures require the proper tools. The development of new instruments is constant. The "new age" laparoscopic surgeons find this new area is fertile ground for their imagination.

Laser

One of the most significant and spectacular new instruments has been a new source of power energy: the Laser.

Expansion and refinement of our knowledge in basic physics have had direct application to the medical sciences. Lasers have been used in macroscopic and subcellular surgery since the 1960s.[5] Kaplan et al.'s work[6] in the 1970's helped initiate the growth of laser surgery. Lasers can now be used for vaporization or extirpation of endometriosis, resection of leiomyomas and excision or ablation of cysts. Micromanipulators have allowed for the use of very small spot sizes resulting in a high degree of precision with relatively low power. The CO_2 laser is a valuable tool for vaporization and precise cutting and has been adapted to a flexible delivery system.[7] The ability of the Nd:YAG laser to provide good coagulation has expanded its use in gynecologic procedures. The advent of new contact probes and flexible fibers will act as a catalyst to expand the possibilities of such laser treatment.

Energy Sources

Alternate energy sources include the laser, both unipolar and bipolar electrosurgery, and the endocoagulator (heat) first described by Semm.[8] No one energy source has yet been defined as superior to the others. All have been found useful in specific situations.

Operating Room and Personnel

The growth of advanced laparoscopic surgery, especially with laser application, has necessitated a radical and progressive restructuring of the Operating Room and its personnel. Extensive training (including both didactic and clinical components) is now a routine requirement for the operating room support nurse and technician. Elaborate safety precautions are required, especially when the laser is used. Laser support personnel will be required to periodically undergo baseline eye examinations in addition to the extensive advanced training education.

Visual Documentation

The use of video in performances of the surgery and visual documentation are vital aspects of advanced endoscopic surgery. Videoimaging has affected the education of the endoscopist and the supporting staff, allowing for simultaneous viewing of the operative field during the procedure as well as taping for future evaluation. Solid state microprocessors such as the charge-coupled device and the metal-oxide semiconductor chip are leading the way and visual documentation is no longer the sole province of the biomedical photographer.

Pelvic Inflammatory Disease

Laparoscopy has had a dramatic impact on the management of both acute and chronic pelvic inflammatory disease (PID). This surgery offers almost 100% accuracy in diagnosis and allows the surgeon to determine the extent of involvement. As discussed in Chapter 8 by Reich, this approach also allows for treatment of acute PID by lysis and lavage. As already mentioned, many of the sequelae of acute PID (adhesions, hydrosalpinx) can also be managed without resorting to laparotomy.

Medicolegal Questions

Medicolegal ramifications affecting endoscopic surgery have been extensively detailed in this book. Although federal regulation seems unlikely, credentialing and ongoing evaluation are important. Perhaps we may witness a new realm of cooperation between attorney and health care provider.

Evaluation

Rapid technical changes have necessitated that evaluation be made in a facilitated manner. Simple laparoscopic surgery was first generally accomplished only 15 years ago. Exponential growth requires equally rapid evaluation to ensure competence and patient safety.

Credentialing

The rapid changes occurring in operative laparoscopy have brought forth both good and controversial results and of course, the inevitable "consequences." For the patient, the performance of laparoscopic surgery is a boon: There is not the inconvenience of even a Pfannenstiel incision; there is less disfigurement of the abdomen; hospital stay is much shorter; expense is decreased; and the probability of postoperative adhesions is reduced. However, there is another side to the coin: The hospital census is diminished, which has resulted in decreased hospital revenue at a time when more expense is required for the highly specialized equipment necessary for current high technologic medical care.

There is another consequence of more insidious importance: the credentialing of surgeons for the performance of advanced laparoscopic surgery. Every gynecologist performs diagnostic laparoscopy; almost all of these physicians perform the simple operative procedures—sterilization, cautery of endometriosis, lysis of simple adhesions. In the minds of many, the transition to "advanced laparoscopic surgery" is minimal and requires little or no specialized training. The instruments may be available in the operating room, ready at the beck and call of the surgeon. There will always be a need to stay "current" (an ego factor that requires the performance of any new procedure). Finally, the results of infertility surgery are not immediately apparent; after all, they may be limited by the pathology regardless of what technique is used, and it is never known what the results might have been in more experienced hands. Credentialing is being stressed here, not in any effort to reduce the number of gynecologic surgeons performing such procedures, but to be certain that all do so with the proper training and experience. The medicolegal aspects of operative laparoscopy and laser laparoscopy will certainly weigh heavily upon the decision to credential surgeons in these modalities. However, as of this writing there are no standards that have been universally accepted by the current certifying agencies. An effort has been made (in the section that follows) to suggest certain guidelines.

The purpose of these guidelines is to assist the credentialing body of a hospital to determine how best to ascertain the competence of an individual for the performance of advanced laparoscopic surgery and laser laparoscopic surgery.

Preparation

The individual must have completed a Residency in Obstetrics and Gynecology, and must be Board Certified or eligible, and have privileges for the same procedures when performed by laparotomy.

The individual must express a special interest in performing these procedures, such interest to be evidenced by reading of the literature and having used audio-visual aids.

The individual shall have completed a course especially designated for advanced laparoscopic or laser surgery. (A short/didactic course does not guarantee competency.) Such a course shall include:

- Didactic material so as to understand the physical principles of the equipment, particularly the laser, and including factors of safety.
- There shall be a "hands-on" aspect in a laboratory for a minimum of ten hours, of which six hours shall be with the use of "tissue."
- The course shall include the use of video for demonstration.

The individual shall then proceed to observation in an operating room for the purpose of:

- Understanding all the equipment, with the capability of operating it.
- Learning the role of nurses, both scrub and circulating nurse.
- Observing by watching video or the teaching side-arm.
- Observing at least five cases of a complex nature, with an optimum of ten cases.

The individual shall operate as the first assistant to an experienced surgeon, preferably with the use of video equipment. (Prior to completion of a course and Preceptorship, a physician may request a credentialed surgeon to join in a case. Under these circumstances, the latter becomes the "surgeon-of-record.") Cases may be simple, but may move on to more complex procedures, and the experience should consist of a minimum of five complex cases. (It is preferable that the individual spend at least one week at a "center" for the purpose of absorbing the total picture. Upon completion, a "certificate of competence" should be signed by the Preceptor.)

The individual shall then schedule their own cases *with* an experienced surgeon as the assistant. Video equipment should be available. This should be done for a minimum of five complex cases.

Credentialing

If an individual has completed a Residency in which advanced laparoscopic surgery or laser laparoscopy is "routine," this will be accepted provided a letter indicating competence is received from the program director.

For those receiving new and special training, the individual should then be observed by those who are already credentialed. Recommendations should be given to the department chairman, who will approve the privileges.

If the laser is to be used for external use, the individual must have special training in colposcopy.

Evaluation

It will be necessary for the individual to have an ongoing experience in the performance of these procedures.

Comment

This book has discussed procedures performed by laparoscopic surgery that previously were accomplished by open laparotomy. Chapter 22 has addressed the impact of endoscopic surgery on the cost of medical care, both direct and indirect. The potential of decreasing hospital stay can have a profound impact on the general medical economy. As Method and Keith have noted, the indirect cost benefits may be the true economic contribution of this type of surgery. According to the Office of Productivity and Technology, in 1982 the financial loss associated with the loss of a single day by a female doing manufacturing work approached $255 (including wages and productivity).[9] By calculating the number of women in the work force, the potential savings in *daily* revenue for each day saved is the astonishing amount of $57.6 million. The cost advantages will continue to be a major benefit of advanced laparoscopic surgery.

The ability to perform laparoscopic surgery has allowed us the opportunity, almost simultaneously, to make the diagnosis, establish the prognosis, and institute therapy.[10] Thus many limitations and restrictions have been removed. The patient is treated and returns to normal health expeditiously and with safety.

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