Sponsored by the AAGL
THE AMERICAN ASSOCIATION
OF
GYNECOLOGIC LAPAROSCOPISTS
"A Global Gynecologic Endoscopic Society"

A
PRIMER
IN
GYNECOLOGIC
ENDOSCOPY

The AAGL gratefully acknowledges the support of the Foundation of the AAGL in providing financial support through the Resident’s Circle Program to assist in underwriting the Resident’s Program.


Reproduction of this document may not be made without the written permission of the AAGL.
PART I: TECHNIQUES

ROBERT B. HUNT, M.D.
Informed Consent for Diagnostic and Operative Laparoscopy

ANDREW I. BRILL, M.D.
Organizing the Operating Room

ANDREW I. BRILL, M.D.
Laparoscopic Access and Instrument Ergonomics

ROBERT M. ROGERS, J.R., M.D., and JOEL M. CHILDERS, M.D.
Laparoscopic Gynecologic Anatomy

ANDREW I. BRILL, M.D.
Principles for the Safe Practice of Electrosurgery and Ultrasonic Surgery

MALCOLM G. MUNRO, M.D.
Cutting, Hemostasis and Tissue Fixation

WILLIAM H. PARKER, M.D.
Morcellation and Tissue Extraction

GRACE M. JANIK, M.D.
Adhesion Prevention

PHILIP G. BROOKS, MD.
Uterine and Patient Preparation

FRANKLIN D. LOFFER, M.D.
Reducing Risks During Hysteroscopic Surgery

LINDA D. BRADLEY, M.D.
Diagnostic Hysteroscopy

PART II: PROCEDURES

RICHARD M. SODERSTROM, M.D.
Laparoscopic Sterilization Procedures

RICHARD P. BUYALOS, M.D., and MALCOLM G. MUNRO, M.D.
Laparoscopic Management of Ectopic Gestation

WILLIAM H. PARKER, M.D.
Adnexal Surgery by Operative Laparoscopy
VICTOR GOMEL, M.D., and MALCOLM G. MUNRO, M.D.
Laparoscopic Fertility-Promoting Procedures and Endometriosis

MALCOLM G. MUNRO, M.D.
Laparoscopic Hysterectomy

MALCOLM G. MUNRO, M.D.
Medical and Surgical Approaches for Uterine Leiomyomas

ANDREW I. BRILL, M.D.
Laparoscopic Retropubic Colposuspension

MALCOLM G. MUNRO, M.D.
Complications of Gynecological Laparoscopy

ROBERT B. HUNT, M.D.
Laparoscopic Complications: Strategies to Avoid Them

PART III: TECHNICAL ASSESSMENT

FRANKLIN D. LOFFER, M.D.
Endometrial Resection/Ablation

LINDA D. BRADLEY, M.D.
Hysteroscopic Management of Abnormal Uterine Bleeding: Polyps and Myomas

FRANKLIN D. LOFFER, M.D.
Non-Hysteroscopic Endometrial Ablation

DAVID L. OLIVE, M.D.
Laparoscopic Surgery: Examining the Indications and the Evidence

DAVID L. OLIVE, M.D.
Hysteroscopic Procedures: Examining the Indications and the Evidence

PART IV: TEST QUESTIONS/WITH ANSWER KEY

Pretest Questions

Answer Key
Introduction

Table 1. Suggested skill levels for the training, certification and credentialing of operative laparoscopy

Level 1 (Basic operative laparoscopy):
- Ablation/removal of mild to moderate endometriosis, including endometriomas < 3 cm in diameter
- Salpingo-ovariolysis of mild to moderate adhesions
- Utero-sacral ablation
- Treatment of ectopic pregnancies.

Level 2 (Advanced operative laparoscopy):
- Resection of moderate to severe endometriosis
- Resection of ovarian and parovarian cysts, including endometriomas
- Oophorectomy ± salpingectomy
- Neosalpingostomy and fimbrioplasty
- Lysis of moderate to severe peritubal, ovarian and abdominal adhesions
- Myomectomy
- Appendectomies.

Optional Level 3 (Innovative/experimental operative laparoscopy)*:
To include the performance of any procedures considered by the institution to be more risky, innovative or experimental than usual (e.g. presacral neurectomies, nodal sampling, etc).

* This level is not usually used in credentialing, rather cases designated as level 3 may be reviewed at regular intervals by an appropriate committee (e.g. Quality Assurance) for complications, indications, etc.

Laparoscopy Training Schematic

Table 2. Suggested skill levels for the training, certification and credentialing of operative hysteroscopy
Introduction

Level 1 (Basic operative hysteroscopy):
- Removal of polyps, small fibroids and lost IUDs
- Metroplasties
- Lysis of mild to moderate synechiae

Level 2 (Advanced operative hysteroscopy):
- Lysis of severe synechiae with obliteration of the uterine cavity
- Endometrial ablation
- Resection of larger fibroids.

Hysteroscopy Training Schematic
PART I

TECHNIQUES
Informed Consent for Diagnostic and Operative Laparoscopy

Purpose

Laparoscopy is an extremely valuable procedure in gynecology and infertility. It may be performed to establish a diagnosis, such as determining the cause of infertility or pelvic pain. It is often used as therapy, such as removing adhesions (scar tissue) or destroying endometriosis.

Procedure

The operation is usually performed with the patient asleep (general anesthesia). In certain instances it may be done under local anesthesia. With the patient appropriately anesthetized, an instrument (cannula) is placed in the cervix and secured with a tenaculum. These instruments enable the surgeon to position the uterus and aid the pelvic assessment. A catheter is placed in the urinary bladder to drain it.

The abdomen is inflated with a gas (usually carbon dioxide or nitrous oxide) to allow adequate intraabdominal visualization. An incision is then made at the navel, through which a telescope (laparoscope) is inserted. One to four incisions are then placed in the lower abdomen. These incisions leave scars one-quarter to one-half inch in length. Through these incisions the surgeon inspects the pelvic structure and performs indicated procedures. Among these are removal of some pain nerves behind the uterus to alleviate menstrual cramps, and suspension to the uterus forward to enhance fertility and reduce pelvic discomfort. A photograph of the pelvic structures is often taken to document the finding. This also helps the patient to understand what was found and done.

After the operation has been completed, the gas is allowed to escape from the abdomen, all instruments removed, and the abdominal incisions are closed with sutures. Often fluid and medications are placed in the abdomen to prevent adhesion (scar tissue) formation. Sometime a dilation and curettage (D&C) is required.

Follow-up

The patient will frequently experience pain in her shoulder, chest, and upper abdominal areas cause by the gas. She will also experience tenderness at the incision sites. These discomforts usually diminish markedly after 2 days. Because fluids are often left in the abdomen to prevent adhesion formation, the patient will frequently leak fluid from the incisions and observe swelling in these areas. This fluid leakage and swelling should disappear within 2 days. There is usually some bruising at the incision sites. This disappears in approximately 2 weeks. Many patients go home the day of the surgery but must be transported by a responsible adult.
Complications

1. Anesthesia: anesthesiologists have made significant advances in improving patient safety; however, anesthetic accidents still happen. If anesthesia is required, the anesthesiologist should discuss these complications with the patient before the surgery. If the patient has had prior anesthesia, she should acquire those records and show them to the anesthesiologist at the time of the preoperative consultation.

2. Hemorrhage: excessive bleeding can occur when developing the portals of entry in the abdominal wall, as well as during pelvic dissection. Both events are in infrequent and can usually be dealt with laparoscopically, but laparotomy is sometimes required. Although the necessity for blood transfusions in laparoscopy is uncommon, the patient should inquire as to the advisability of donating her own blood prior to the procedure to avoid receiving blood from donors, thus lessening the change of such sequelae as hepatitis and AIDS.

3. Gastrointestinal injuries: injuries to the intestinal tract occur approximately 1 per 500 operations. This may happen when establishing the portals of entry from the instruments as well as during pelvic dissection. This is a serious complication and must be rectified. The repair usually requires major surgery. Although a colostomy is a possibility, it is a remote one.

4. Urologic injury: because much dissection is done around the drainage tubes from the kidney (ureters) or the urinary bladder, there is always the possibility of injury to one of these structures. These may be minor or serious, resulting in major surgery and even, rarely, loss of a kidney.

5. Gas emboli: a serious complication is passage of gas used to inflate the abdomen into a major blood vessel, from which it may travel to the patient’s heart and lungs. The surgeon uses several checks to lessen the possibility.

6. Phlebitis: the patient may experience tenderness along the vein used for intravenous administration of fluids and medications. This responds to warm compressed and is usually temporary. Occasionally, a small lump at the intravenous site will persist.

7. Incisions: infrequently an incision will become infected, requiring warm compresses, antibiotics, and drainage.

8. Pelvic infections: the patient will sometimes develop a pelvic infection after surgery. She usually receives an antibiotic during surgery to lessen this prospect. When infection develops, she must notify the physician immediately.
9. Allergic reactions: several medications are used during surgery, and there is always possibility of a reaction to one or more of them. Appropriate steps are taken to counteract it.

10. Ovarian failure: the ovary(ies) may go into permanent failure after surgery. This is usually associated with extensive ovarian surgery, such as removal of cysts.

11. Neurologic injuries: pelvic nerve injuries may occur when extensive pelvic dissection is required. These are most often characterized by temporary numbness or tingling in the abdomen or lower extremities, but muscle weakness may occur rarely and be permanent. Similarly, weakness of the upper extremity has been reported, but fortunately, is very infrequent.

12. Failed procedure: occasionally the surgeon will have to terminate the operation due to technical problems or because the procedure is inappropriate for the disease, as in the discovery of a pelvic malignancy. Major surgery would be done at that time only for an urgent problem, and, if appropriate, after consultation with the family.

13. Death: catastrophic complications resulting in death of the patient are rare.

**Follow-up**

The patient should call the office the first postoperative day to advise us as to any problems she is having, and to make her return appointment for 3 weeks. She should remain out of work for 1 week, and should report any unusual signs or symptoms such as unusual vaginal discharge, fever, or increasing pain.

**Conclusion**

We have an advanced operative team. Our equipment is modern. We are constantly reviewing our techniques and instrumentation to maximize patient safety. The patient is encouraged to ask many questions as necessary to clear up doubts.
INFORMED CONSENT: Diagnostic and Operative Laparoscopy

I have read the preceding pages and understand what I have read. Dr. Hunt and his staff have given me ample opportunity to ask questions on specific points. I would like the follow restrictions to apply:

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

__________________________________  _________________________
Signature                      Date

__________________________________  _________________________
Witness                       Date

Please initial each page of consent form, sign the last page, have it witnessed (may be husband), and return the entire form to:

Dr. Robert Hunt
319 Longwood Ave.
Boston, MA 02115
Organizing the Operating Room

Andrew I Brill, M.D.
Professor
Director of Gynecologic Endoscopy
University of Illinois at Chicago
Fundamentally, laparoscopic surgery differs from its laparotomic counterpart only by its particular mode of access. However, it is intrinsically more difficult to perform than laparotomy due to the indirect palpation of tissues through a finite number of immutable ports, the coincident restriction of axial freedom, and the replacement of normal stereoscopic three-dimensional visualization by an indirectly referenced two-dimensional video image. Despite these challenges, given proper surgical case selection and the requisite physician training, it promises to result in at least equivalent results, better cosmesis, less postoperative pain, and faster recovery. Nevertheless, growing concerns over scales of remuneration, relative costs, complications, and the lack of prospectively gathered evidence have caused both gynecologist and health insurer to think twice about the laparoscopic approach.

The greatest challenge for the laparoscopic surgeon is to perform the surgical procedure as efficiently as possible while minimizing the risk for complication. "Me very roots of this process actually begin to take form during the patient's first office visit, when risk assessments and strategic planning become inextricably linked to patient psyche, medical and surgical history, phenotype, abdominal scars, distribution of fat, native anatomy, and underlying pathology. Once admitted to the hospital, communication between the surgeon and all operating room personnel forms the next level of preemptive planning.

**Why Strategic Planning?**

The desire to prematurely rush the patient into the operating room must be resisted. I define "prematurely" as entry before proper choreography of personnel, relevant equipment, and the surgical environment. The need for thoughtful orchestration before incubation is predicated on two recurrent and predictable facts: First, that with the passage of time, sub-optimal attention to detail at the beginning of the case can insidiously mushroom, potentially compromising both technical success and patient safety (lest we not forget: Laparoscopy = Foreveroscopy). And second, certain patient injuries can by prevented by attention to detail at the outset of the case.

**The Surgical Environment**

The surgeon should strive to "sense" the operating room as a dynamic environment which consists of lighting, temperature, space, a large complement of complex equipment, and a supporting cast of other surgeons, nursing staff, the anesthesiologist, and the patient. Ideally, all of these forces should be in functional balance before the patient is brought into the operating room. Your stewardship demands that you settle for nothing less.

**Preparing the Enterprise: Environment, Equipment, and Players**

The thermostat should be adjusted to ensure that the room is adequately warmed for the disrobed patient. The operating table should be completely flattened, lowered, untilted, and checked for equal positioning between the two overhead lights. The central anesthesia cart should be mobilized to liberate space for carts holding endoscopic equipment that will require unimpeded visual access. For the right-handed surgeon, the draw sheet on the operating table should be exaggerated over the left side of the table.
(and visa versa, if left-handed) to maximize the ability to wrap the upper extremity to the side of the torso. Each endoscopic: instrument cart should be checked for proper central electronic function. The light source should be turned on to check for viability. The entire video system must be checked for imaging and quality on all monitors. With videotape in hand, visual documentation requirements should be reviewed. The insulator should be switched on and the carbon dioxide tank checked for adequate pressure. If a laser is to be used, it should be keyed to confirm adequate function, and anticipated power settings as well as the need for protective measures reviewed with nursing. Desired settings for the electrosurgical generator should be discussed with the circulating nurse. Nursing should be informed of any alternative methods and equipment that will be used for peritoneal access, tissue dissection, tissue removal, peritoneal washings, and facial closure. An adequate supply of warmed irrigation solution should be confirmed. Solutions such as methylene blue and vasopressin should be readied in the proper dilutions.

The anesthesiologist should be concisely advised of the surgical plan, and as required, about the need for an orogastric tube, to avoid nitrous oxide as an induction agent, to use a warming bear-hugger for an anticipated long surgery, to confirm the administration of prophylactic antibiotics, to recheck that the patient was typed and screened, to mark the mid-clavicular line for left upper quadrant access, and to anticipate the need to wrap one or both of the patient's arms.

For operative hysteroscopy, the anticipated types of dilators, sheaths, telescopes, elements, and electrode configurations should be discussed. Furthermore, adequate volumes of warmed non-electrolyte solutions should be established, and the plan for fluid delivery and deficit monitoring of effluent reviewed with nursing and the anesthesiologist.

The Patient: Introduction and Preparation

The patient should be eased into the surgical environment by personal introductions, a comfortable ambient temperature, and relative quietude. Before transfer is made to the operating table, all gowns should be untied, unsnapped, and loosened for eventual removal. Warm blankets facilitate comfortable transfer. If acceptable to the anesthesiologist, the patient should be asked to position her buttocks slightly beyond the hollow toward the foot of the operating table (steep Trendelenburg inevitably leads to upward sliding). Significant repositioning after paralysis and intubation may convert a simple and predictable vertical axis into a scoliotic mismatch.

The final patient position is readied only after intubation, the endotracheal tube has been secured, and the anesthesiologist has given his or her consent. For operative laparoscopy, Allen-type stirrups, which provide both foot and knee support, are attached to the side rails of the table. Stirrup sided-ness can always be identified by recognizing that when properly positioned, the boot always rests on the inside of the stirrup. After raising the legs simultaneously, they are set into the stirrups and lightly strapped into position. The foot of the table can be lowered only after the position of the hands are checked and protected from potential injury by entrapment. The position of the buttocks relative to the edge of the table can then be readjusted as needed. The stirrups are then adjusted to insure that both feet are flatly supported, there is no undue pressure on the calf, the level of the knees are equal and equilibrate to the height of the iliac crests, and
that lateral rotation of the femoral head is minimized. The patient's arm on the surgeon's side should then be carefully wrapped with the under-sheet by first lifting this sheet, adducting and pronating the upper extremity, wrapping the sheet over and around the arm, and finally tucking it directly under the torso to secure its position. Any contact between the hand and metal components (such as arm of the stirrup) should be protected by wrapping with a towel or interposing a piece of egg crate foam rubber. In cases of operative hysteroscopy, candy cane type stirrups are preferable and can be safely used in place of Allen-type stirrups, as long as every effort is made to avoid excessive elevation and external rotation. More importantly, any leaning on the inner extremity must be prohibited.

Best done with an empty bladder, a systematic pelvic exam should then be performed to assess all pelvic compartments. The axes of the cervix and uterus are imprinted to avoid mishap during dilatation or insertion of a uterine elevator. A rectal exam is used to critically palpate the posterior pelvis for relative mobility and possible modularity of the posterior uterus, adnexae, uterosacral ligaments, and rectovaginal septum. As needed, the lower abdomen may be partially shaved. Antiseptic preparation of the abdomen, vulva, thighs, and vagina should be performed in a systematic and thoughtful fashion. The umbilicus harbors the greatest risk for infection, and should be assiduously cleansed to its base. After antiseptic lavage, the bladder may be simply emptied with a straight catheter for shorter cases, or drained with a Foley catheter for longer cases or when dissection of the bladder is anticipated by the nature of the procedure. A return electrode, capable of return electrode monitoring (REM), should be placed horizontally upon the upper half of a dry and non-keratotic aspect of the anterior thigh. The patient is then systematically draped in the standard fashion. For operative hysteroscopy, draping should include the proper placement of a fluid collection drape below the buttocks.

The anterior lip of the cervix is grasped with a tenaculum while a Grave's or weighted speculurn is used to maintain adequate vaginal girth for its visualization. After sounding the uterine cavity, the internal os is then progressively dilated for operative hysteroscopy or a uterine elevator is carefully placed for operative laparoscopy. In nulliparas or when the cervix is stenotic, the internal os may need to be dilated before insertion of larger elevators such as the Humi. Without question, the uterine elevator is one of the most important instruments used during the course of any operative laparoscopic surgery. Therefore, it makes no sense to allow this instrument to senselessly spin and turn into the rectal recess, where the surgeon has to repeatedly grope outside the operative field for its retrieval. To position a curvilinear uterine elevator into a relatively fixed anterior and posterior axis, where it can be readily accessed for traction-countertraction maneuvers, simply pack the vagina superficially with open 4x4 sponges both anteriorly and posteriorly along the shaft of the elevator before the weighted speculum or posterior blade of the Grave's unit is removed. A sterile glove can then be used to cover any portion that protrudes into the operative field.

The Finishing Touches

Instrument carts can then be strategically rolled into positions that maximize physical access to equipment and allow the primary surgeon and assistants to comfortably
maintain a visual dialog with the video screen(s) and insulator. Pedals to the
electrosurgical generator (ESU) and laser are positioned and stabilized for ready access
by the primary surgeon. The surgeon should review the ESU pedal logic for "bipolar",
"coagulation", and "cutting" modes. We must never forget that any endoscopic
instrument within the peritoneal or uterine cavity can be quickly transformed into a lethal
weapon whenever the visual attention of the surgeon is interrupted by the need to search
for a foot pedal in the midst of darkness. The main instrument table and scrub nurse
should then be positioned to promote visual communication, and to maximize both the
surgeons' and scrub nurse's unfettered access to instrumentation.

In cases of operative laparoscopy, orchestration of the surgical plan is finalized by
organizing the surface of the operating field. While minimizing the risk of undue tension,
all vital conduits have to be organized and logically fastened to the surgical drapes.
Tubing from the insulator and the suction-irrigator must be fastened into position.
Electrical cords for both monopolar and bipolar devices should be secured and checked
for proper connection to their respective electrosurgical outputs. And lastly, the light
fiber bundle cable and camera cord should be affixed in parallel with extra leeway to
allow for traction and mobilization during the course of surgery.

For operative hysteroscopy, suction and instillation tubing must be securely
organized in a similar fashion above the operative field, and suction tubing connected to
the collection drape (and when available, the floor evacuation pod). If a formal fluid
monitoring device will be utilized, it must be properly positioned, primed, and connected
at both output and input ends.

Ideally, the most commonly used laparoscopic instruments can be securely
housed for ready access within a pocketed towel or disposable saddlebag which is
secured to the anterior thigh drape on the surgeon's side. A typical complement would
include the suction-irrigator assembly, a metal probe, a grasper, the Kleppinger bipolar
forceps, and a monopolar shears. Since hemostasis of active bleeding is best
accomplished with coaptive bipolar coagulation, the Kleppinger device and bipolar cord
should be tested before the case is initiated. This is done by simply grasping the edge of
a moistened sponge with the tines of the forceps, and checking for the emission of steam
on activation.

In summary, the master surgeon is the conductor of his or her surgical environment.
Most importantly, patient safety is seamlessly linked to the level of preparation and
attention to detail before the initiation of surgery. The "success" of any surgical
procedure must be critically measured not only by its achievement in the absence of
complication, but also by the degree of fluidity and efficiency associated with the
procedure.
Laparoscopic Access and Instrument Ergonomics

Andrew I. Brill, M.D.
Professor
Director, Gynecologic Endoscopy
Department of Obstetrics and Gynecology
University of Illinois at Chicago
INTRODUCTION
The art of laparoscopic surgery is predicated on previsualizing the needs of the contemplated procedure. Patient safety and technical efficacy is inextricably linked to how carefully the patient is evaluated preoperatively. Choosing the best method for accessing the peritoneal cavity depends upon patient phenotype, abdominal wall morphology, and the anatomic configuration of underlying vital anatomy. Since no particular methodology is technically feasible and necessarily the safest approach for every patient, it is incumbent upon every laparoscopic surgeon to be well versed in alternative procedures for insufflation and entry into the peritoneal cavity. We must be reminded that most significant surgical accidents occur during insertion of the Veress needle and the primary or accessory trocars.

Every effort should be made to ascertain whether the patient is at risk for having intraabdominal adhesions between the underlying bowel and anterior abdominal wall. Any prior operative report should be assiduously reviewed for documented adhesions. Each discharge summary should be perused for treatment of postoperative peritonitis. Any patient having undergone laparotomy (regardless of type of incision), especially those with prior bowel resection or omentectomy, should be considered to be at significant risk.

The preoperative examination should include evaluation of umbilical depth and distribution of abdominal wall adiposity. Extremes of body weight are reasons for extra caution. A stout patient with centripetal obesity endows the greatest strategic challenge for uneventful insufflation and trocar entry. In thin patients, especially those with an android pelvis and prominent sacral promontory, the depth of the umbilicus can lie within 1-2 centimeters of the anterior surface of the aorta; the proximity of the retroperitoneal vessels will tolerate only the smallest margin of error.

Any surgical scars on the abdomen should be individually noted and correlated with antecedent surgery. The abdomen should be palpated for evidence of hepatosplenomegaly. After induction of general anesthesia, palpation of the aortic bifurcation and sacral promontory should be attempted for spatial orientation, and the iliac crests located and then correlated with the position of the umbilicus. The abdominal wall should be grasped and elevated between the thumb and index finger to ascertain the depth of subcutaneous fat and the degree of laxity. If a pelvic mass extends out of the true pelvis, it should be carefully heeded by outlining with a sterile pen.

INSERTION OF THE VERESS NEEDLE AND INSUFFLATION
Any particular methodology used for blindly inserting a sharp instrument into the peritoneal cavity must account for the physical dimensions of the device, the distribution and amount of abdominal panniculus, the anatomic position and depth of the umbilicus, the degree of abdominal wall laxity, the presence of any prior abdominal incision, patient positioning, and a keen understanding of the anatomic positions of the underlying viscera and large retroperitoneal blood vessels. No particular technique is universally applicable, or for that matter foolproof. Strategic planning, knowledge of relevant anatomy, and carefully controlled maneuvers are the best insurance against catastrophic misadventure.
In the abdomen that has not been previously laparotomized, sharp entry is best initiated directly through the umbilicus. Regardless of body mass, this is the thinnest portion of the abdominal wall. There is no subcutaneous adipose tissue between the skin and fascia in this region, and the lower border is composed of peritoneum and deep fascia that are fused with the overlying skin. This unique anatomic relationship evolves postnataally when the umbilical scar is drawn firmly against the umbilical ring and linea alba by fibrous remnants of the umbilical vessels and urachus. The retracted umbilical fossa represents the region of abdominal skin where it is fused to the underlying linea alba. Union of the peritoneum to the postnatal umbilical plate prevents stretching on sharp entry.

In most women, the aortic bifurcation rests between the 4th and 5th lumbar vertebrae, or within 1.25 centimeters above or below a line drawn between the iliac crests. Nevertheless, due to anatomic variation it may be located either above or below these disc spaces. The umbilicus is most commonly located between the 3rd and 4th lumbar vertebrae. However, this relationship is quite variable. The position of the umbilicus relative to the aortic bifurcation is negatively correlated with body mass; it more commonly rests caudal to the bifurcation in overweight and very obese women.

Altering the patient’s position can affect the surgeon’s viewpoint regarding important landmarks such as the sacral promontory and sacral hollow. Premature Trendelenburg positioning can shift the position of the bifurcation cephalad to rest more directly below the umbilicus.

**Equipment**

Establishing the pneumoperitoneum requires functional knowledge of the insufflator and the Veress needle. When the insufflator is turned on, adequate tank pressure should be confirmed by observing that the carbon dioxide pressure gauge registers in the green. Once the insufflation tubing is connected to the insufflator, the pressure shut-flow mechanism should be checked for proper operation. Turned to high flow (6 liters/min.), the insufflation pressure should register 0. If the flow control is then turned to low flow (1 l/min.) and the tubing is kinked, the pressure indicator should quickly rise to 30 mm and the flow of carbon dioxide should drop to zero.

The Veress needle should be disassembled to inspect whether the spring is properly loaded, and reassembled to confirm that the inner and outer sheath are properly mated. The stopcock and holding screw should be tightly fastened. The blunt tip of the needle should be pushed against something flat to confirm that it easily retracts and springs forward smoothly and rapidly. Finally, the patency of the needle is checked by flushing with saline. The insufflation tubing is then connected to the Veress needle. Low flow should register at 1 l/min., and high flow should at 2 - 2.5 liters/minute (maximal flow is limited by the 14 gauge diameter of the needle). If the static pressure registers greater than 3 mm, there is blockage in the hub or shaft of the needle.

**Infraumbilical Incision - Rationale and Technique**

Inspection of the umbilical fossa usually reveals a sunburst of Langer’s lines that run vertically. Whenever possible, a dominant vertical fold is chosen for the site of incision. Since the topographic alignment of collagen bundles and lines of tension will run in a parallel direction,
this type of incision leads to the best cosmetic result. If the navel is naturally everted or flat with the abdominal wall, the surgeon’s best choice is to make a transverse incision within the inferior rim.

With the patient in a supine position, the inferior margin of the umbilicus is grasped and lifted with the surgeon’s nondominant hand using an Allis clamp and rolled outward, caudally, and then upward at a 45 degree angle. A Kelly clamp is then used by the assistant to spread open the umbilicus to expose the base of the fossa and delineate the skin folds. Using a #11 blade, a superficial vertical stab incision is started at the base of the fossa and extended caudally up to the jaws of the Allis clamp. A superficial depth of incision can be maintained and bleeding is minimized by supinating the wrist as the knife blade progresses caudally along the elevated tissue plane. The Kelly clamp is then used to bluntly dissect the umbilical ring free of tissue investments, first in parallel and then at 90 degrees to the incision, in order to develop an avascular aperture of sufficient girth to accommodate the primary trocar. The Allis clamp is removed after the size of the incision is checked for adequacy with the back of the scalpel holder (about 1 cm in width) or by inserting the surgeon’s small finger.

**Insertion of the Veress Needle**
The propensity for the Veress needle to terminally rest in a preperitoneal space is dependent upon the angle of insertion coupled with the thickness of the abdominal pannus. Conventional teaching dictates that in order to penetrate the thinnest part of the abdominal wall and minimize the risk of traumatic injury to the retroperitoneal vessels. The Veress needle should be inserted through the inferior rim of the umbilicus and directed in the midline at a 45 degree angle toward the hollow of the sacrum.

Using MRI and CAT scans (on unanesthetized women in the supine position) to measure the thickness of the abdominal wall and critical distances to the great vessels, Hurd reported that preperitoneal placement and vascular injury with a standard Veress needle (11.5 centimeters in length) is least likely using the standard approach in nonobese women. In the overweight patient, however, similar outcomes require modifying the point of needle insertion to the base of the umbilicus. Preperitoneal insufflation is least likely to occur in very obese women only if the needle is placed through the base of the umbilicus at a 90 degree angle. The fact that the umbilicus is usually caudal to the bifurcation in this weight group helps support the relative safety of this modified approach.

**Elevation of the Abdominal Wall and Veress Needle Insertion**
No particular method for abdominal wall elevation has been demonstrated to be singularly superior. Regardless of technique, it should be comfortable for the surgeon, the abdominal wall must be securely grasped to provide controlled countertension, and the amount and angle of abdominal wall elevation should naturally accommodate the safest and most logical approach to the peritoneal cavity.

Two methods are most commonly used for elevating the abdominal wall. In the first, the skin and fat on either side of the umbilicus are grasped either manually or with towel clips (taking great care to grasp only the subcutaneous tissue) and the abdominal wall is elevated at a 90
degree angle. Alternatively, the skin and fat of the abdominal wall are manually grasped midway between the mons pubis and umbilicus and elevated caudally at a 45 degree angle.

With sufficient abdominal wall elevation, the Veress needle is then inserted under maximal control. While resting the outside of the hand on the patient’s abdominal wall, the needle is grasped midway along the shaft like a dart and gently passed into the infraumbilical incision—either at a 45 degree angle in the nonobese and overweight patient, or perpendicular to the abdominal wall in the very obese patient. As the needle is passed through successive layers of the abdominal wall, two scenarios of resistance-followed-by-give will be felt as it meets and traverses the fascia and then the peritoneum. A distinct click can often be heard as the blunt tip portion of the Veress needle finally springs forward into the peritoneal cavity. The needle is then aimed in the midline toward the uterus, away from the pelvic blood vessels, and toward the hallow of the sacrum.

Intraperitoneal location is confirmed by satisfying an orderly series of tests. The needle is tilted in an arc to check whether the pivot point on counter-swing is midway down the shaft rather than at the tip of the needle. A 10 cc syringe with 5 cc of saline is then connected to the Veress needle. It is aspirated to assess whether any blood or bowel contents enter the barrel of the syringe. The saline is then instilled and flow should proceed without resistance. On reaspiration, no saline should return. The stopcock is left open and the syringe is disconnected. Several drops of saline are instilled into the hub of the needle which should rapidly fall into the abdominal cavity on elevation of the abdominal wall. The surgeon should then be able to advance the needle 1-2 cm deeper without encountering any resistance.

Once the surgeon is certain that the tip of the needle lies within the peritoneal cavity, the insufflation line can be connected. The flow of carbon dioxide should be turned to 11/min., and the indicator on the machine for total carbon dioxide infused should be reset to 0. The pressure in the abdomen during initial insufflation should register less than 10 mm. When the needle is correctly placed, the peritoneum should effectively seal it off; if carbon dioxide bubbles out along the shaft during insufflation, one must suspect that the needle tip is migrated into a preperitoneal locale.

The first definitive sign that the Veress needle lies in the abdominal cavity is the loss of the dullness to percussion over the liver during early insufflation. The abdominal wall should continue to expand symmetrically with loss of the sharp contour of the costal margins. Deep palpation of an upper quadrant should be equally palpable as elevation at the contralateral lower quadrant.

If a high insufflation pressure is noted or there is no flow, the needle should be rotated to assess whether the opening in the shaft is resting on the abdominal wall, omentum, or bowel (the inflow hole is always on the same side of the needle as the stopcock). High pressure may also be secondary to a small piece of tissue blocking the needle opening, which is usually dislodged by flushing vigorously with 2-3 cc of saline.
Insufflation should not be continued if the surgeon is uncertain about the location of the tip of the Veress needle. If the static pressure remains high, the needle should be withdrawn. Any preperitoneal gas pocket should be evacuated before reinsertion is attempted. If a second or third attempt is successful, it is advisable to temporarily inflate the abdominal cavity beyond 25 mm to distend the peritoneum against the abdominal wall in preparation for trocar insertion. If the needle cannot be comfortably and successfully inserted into the peritoneal cavity after three attempts, an alternative method for insufflation should be used (three strikes and you’re out!).

Alternative Methods for Insufflation

Alternative methods for insufflation may be required when faced with the very obese patient or when conventional methods are contraindicated or fail to produce an adequate pneumoperitoneum. Recalcitrant perseverance in the face of failed safety checks can be a prescription for disaster!

In difficult cases, the pneumoperitoneum can be safely and effectively introduced via the cul-de-sac. With the patient in moderate Trendelenburg position, a single tooth tenaculum is used to grasp and place the posterior cervix on anterior traction to tauten the posterior vaginal fornix. Using a long Veress needle (17 cm), the tip is placed precisely in the midline, nearly 2 centimeters behind the junction of the rugae of the vaginal vault and the smooth epithelium of the cervical lip, and slowly advanced no more than 3 centimeters. After attaining an adequate pneumoperitoneum, the needle should be removed only under direct laparoscopic vision. This technique should not be used in the presence of a cul-de-sac mass, severe rectovaginal endometriosis, fixed uterine retroversion, or whenever vaginal vault surgery has been performed.

Insufflation can also be accomplished by transuterine insertion of the Veress needle into the peritoneal cavity. With the patient placed in a moderate Trendelenburg position, the anterior lip of the cervix is grasped with a single tooth tenaculum and placed on traction. A long Veress needle is then inserted into the uterine cavity in the midline and used to antevert the uterus away from the sacral hollow, rectosigmoid, and large retroperitoneal vessels. Safety is maximized by directing this step with the aid of intraoperative sonography. While holding the collar of the Veress needle, the fundus is penetrated and Intrapерitoneal location is presumed by perceiving the spring release of the needle upon entry. The uterus and adjacent structures are perused for bleeding or injury, and the needle is removed under direct laparoscopic vision. This technique should not be used in the presence of leiomyomata, possible pelvic infection or pregnancy, and whenever there is a risk of adhesions between the bowel and fundus of the uterus (e.g., prior myomectomy or hysterotomy.

**PRIMARY TROCAR-CANNULA INSERTION**

**Insertion After Creating a Pneumoperitoneum**

As with the Veress needle, insertion of the first trocar is a blind procedure and associated with significant complications. Safety is maximized by understanding the construction and function of each type of trocar and by rigorously adhering to a logical methodology. Since the amount of thrust required to enter the peritoneal cavity is substantially greater with reusable trocars,
physicians of smaller stature and musculature may increase their margin of safety using disposable devices.

At the onset, all moveable parts of a reusable trocar should be inspected for tightness and function. This is especially important when the valve is of trumpet type, which should be checked to ensure that it is easily depressed and spontaneously returns to its closed position. Miscellaneous untightened parts including screws, nuts, and retention rings are notorious for ‘spontaneously’ shedding themselves onto the floor of the operating theater.

Disposable trocars with a safety shield should be checked to see whether the spring-loaded mechanism is functioning properly by triggering and witnessing engagement through a tracted gauze pad. The safety shield should not be considered to be fail-safe and does not always prevent injury to the underlying viscera.

The signature of controlled entry into the peritoneal cavity is minimal thrust force. Any trocar dystocia must be remedied by stretching or extending the incision to accommodate the full diameter of the assembly. Furthermore, if the intraumbilical incision is of insufficient size, the safety shield may hang up at the skin and rendered unable to spring back into position once the sharp tip has entered the abdominal cavity. This is usually signified by meeting excessive resistance while trying to introduce the trocar through the abdominal wall defect.

Increasing the abdominal pressure to 25 mm before trocar insertion increases the volume of safety, provides better countertraction, and pushes the peritoneum more firmly against the abdominal wall. In the unoperated abdomen the trocar is directed into the vertical skin defect at the inferior base of the umbilicus. The girth of the incision is assessed by placing the distal trocar assembly into the umbilical defect while the abdominal wall is left untracted.

The trocar is held in the palm of the dominant hand and the outer aspect of the obturator is firmly secured against the thenar eminence and pushed into the sheath. The index or middle finger is extended down the shaft of the trocar sheath to act as a brake, preventing sudden and deep advancement. In the presence of a pneumoperitoneum, further elevation of the abdominal wall is usually unnecessary in most patients. If the abdominal wall is thin and muscular, a towel clip can be placed near the inferior rim of the umbilicus for additional elevation and countertraction. In very obese patients, the towel clips are retained on either side of the umbilicus and used to facilitate trocar insertion at a perpendicular angle.

Additional lower abdominal wall elevation and countertraction can be afforded by carefully leaning the side of the surgeon’s nondominant forearm against the abdomen above the umbilicus. Using a slow, steady, and rotational motion, the trocar is initially inserted perpendicularly to penetrate the skin and subcutaneous fat. In the nonobese patient, it is then tilted cephalad to a 60-70 degree angle, directing the tip into the abdominal cavity by aiming midway between the sacral promontory and the bladder. If the patient is obese, trocar insertion should be completely perpendicular to maximize the shortest route to the abdominal cavity.
If a reusable trocar is used, the first indication of entry into the peritoneal cavity will be a loss of resistance followed by an audible “whoosh” if the obturator is perforated along its length. To prevent inadvertent withdrawal from the peritoneal cavity, the sheath should be gently advanced as the obturator is withdrawn. If a disposable trocar is used, the surgeon should appreciate an audible click as the safety shield is engaged as the peritoneal cavity is entered. This requires a modicum of silence in the operating theater. An audible “whoosh” can be heard on opening the side port. The laparoscope is inserted and the underlying bowel and mesentery should be inspected prior to tilting the patient into Trendelenburg position.

**Direct Trocar Insertion**

Insertion of the primary trocar can be accomplished without the aid of a prior pneumoperitoneum. The safety of this approach is predicated on elevation of the abdominal wall, using sharp instruments, and a firm knowledge of anatomy. Since safety is dependent upon the mobile abdominal contents to move away from the sharp instruments, this technique should be reserved for patients who have not undergone previous abdominal surgery. Furthermore, insufflation is also advisable in very thin and markedly obese patients.

The primary benefits of direct trocar insertion are shortened operating time and elimination of the risks associated with the Veress needle including pelvic vessel laceration, bowel wall perforation or insufflation, gas embolism, failed pneumoperitoneum, and subcutaneous or subfascial insufflation. It can be further argued that a flaccid abdomen permits higher elevation of the abdominal wall, less force to achieve trocar insertion, and easier proprioception of each layer during trocar insertion.

After an intraumbilical incision is performed, the trocar is directly inserted into the abdominal cavity while the abdomen is held upward. It must be carefully aimed for the pelvic hollow, and slowly inserted while perceiving each layer upon penetration. On removal of the obturator, the abdominal wall is slightly elevated and the laparoscope is inserted to confirm the presence of bowel in the visual field. The peritoneal cavity is then insufflated and the underlying bowel, mesentery, and vessels are carefully perused for possible injury.

A unique complication of the direct technique is perforation of the omentum as it adheres to the peritoneum. When this occurs, the pneumoperitoneum will elevate the omentum partially off the underlying bowel, and a curtain of omentum will appear before the laparoscope as an abdomen seemingly filled with adhesions. To correct this, the tip of the laparoscope is withdrawn back into the sleeve, the sleeve is brought perpendicular to the abdomen, and the omentum will slide off the trocar onto the bowel.

**PERITONEAL ACCESS WHEN INTRAABDOMINAL ADHESIONS ARE SUSPECTED**

The presence of adhesions between the bowel and the anterior abdominal wall are the enemy of every laparoscopist. Whenever suspected, alternative techniques for insufflation and/or access to the peritoneal cavity should be utilized.

**Open Laparoscopy**
With open laparoscopy, the abdomen is first entered through a small umbilical incision under direct vision. This technique eliminates the risk of sharp trauma to the retroperitoneal vessels and minimizes the risk of entering the lumen of adherent bowel. However, to exercise the same degree of caution used during laparotomy, visual access must remain unimpeded and the underlying anatomic relationships should be predictable. In some patients, limiting the initial incision and subsequent dissection to this region of the abdominal wall can be visually and difficult because of anatomic variation of the umbilicus itself, a large abdominal panniculus, and scarring or retraction secondary to a prior midline laparotomy. Prior laparotomy in the vicinity of the umbilicus can alter dramatically the usual subumbilical anatomic relationships between the linea alba, rectus muscles, properitoneal adipose tissue, and the peritoneum. Tissue planes can become unrecognizable secondary to fusion of the peritoneum and overlying fascia by scar formation, attenuation of the fascial plane, and fixation of the rectus muscles. Occasionally, especially when a prior abdominal incision has been extended lateral and superior to the umbilicus, the bowel is attached directly to the abdominal wall below the umbilical fossa, anatomically annealed to the fascia without any discernible layer of peritoneum. In this situation, injury to the bowel will not necessarily be avoided by maintaining an awareness of the depth of incision of the fascial layers. Categorically then, entering the lumen of the bowel upon incision of the fascia during open laparoscopy remains one of the rare but predictable complications of this technique.

The skin of the lower umbilical fold is held under tension by two Allis clamps, incised vertically for a distance of 1-3 centimeters, beginning inside the umbilicus and extending it inferiorly. The Allis clamps are repositioned on the skin edges which are retracted laterally with S-shaped retractors. The cleavage plane is enlarged and the deep fascia cleaned by inserting closed scissors and then bluntly dissecting as they are separated using a spreading maneuver. Grasped with two small Kocher clamps, the fascia is raised, incised transversely, and bluntly enlarged. With the S-shaped Kocher retractor below each fascial edge, a suture of sufficient tensile strength is passed through each edge and tagged. If the peritoneal cavity has not been inadvertently entered, it is exposed with the S-shaped retractors and then gently entered by spreading with a hemostat. After affixing the cone sleeve to the shaft appropriate for the thickness of the abdominal wall, the blunt cannula is inserted into the peritoneal defect. Insufflation is initiated. The tagged sutures are pulled upward and threaded into the V-shaped suture of the cannula to anchor the fascia firmly against the cone to provide an airtight seal. The blunt obturator is removed and the laparoscope inserted. When the procedure is completed, the cannula is withdrawn after desufflation and the fascia is approximated using the previously tagged sutures.

**Left-upper Quadrant Insertion Site**

Using the left upper quadrant as a site for insertion of the Veress needle for creation of a pneumoperitoneum and primary trocar insertion virtually eliminates the risk of inadvertent bowel injury and trauma to the large retroperitoneal vessels. This approach is contraindicated in the rare patient having undergone spelling or gastric surgery. Before initiating this method, the gastric contents must be aspirated with a nasogastric or oral gastric tube. The initial skin incision is made with a scalpel between the left midclavicular and anterior axillary lines (which is lateral to the superior epigastric vessels) either just below the left costal margin or at the 9th or 10th intercostal space. The Veress needle is perpendicularly inserted shallowly into the
peritoneal cavity by holding it between the index finger and the thumb with the wrist stabilized on the abdominal wall. After several ‘pops’ signaling the various tissue layers, the loss of resistance signals entry into the peritoneal cavity (two pops- intercostal or three pops-subcostal). After insufflation, a 5-mm trocar is inserted into the peritoneal cavity below the last rib between the midclavicular and anterior axillary lines, again perpendicular to the anterior abdominal wall. A 5-mm telescope is then inserted to confirm safe entry and peruse the subumbilical area for anatomic freedom.

INSERTION OF ACCESSORY TROCARS

The site and size of accessory trocars depends upon the anatomic configuration of the pelvic viscera, the cadre of instruments for the chosen procedure, and the type of surgery to be performed. They must be arrayed so that they are not too close to each other to prevent interference between the tops of the trocar sheaths and striking one another within the surgical field. Likewise, an accessory port placed too close to the plane of the primary trocar will inhibit simultaneous access to the surgical field. Ideally, accessory trocars should be inserted at 90 degree angles to each other, forming an equilateral triangle or diamond matrix around the operative site. Each point of entry should be chosen to maximally aid the surgical procedure.

Before inserting any accessory trocar, the superficial epigastric vessels and larger branches should be identified by transillumination. This is not always possible in very obese patients or in the presence of a dense surgical scar. The inferior epigastric vessels should be individually mapped as they depart from the space bordered medially by the medial umbilical ligament and laterally by the exit of the round ligament into the internal ring. Two companion veins, railroad-track in appearance, can often be seen to run parallel below the surface of the pulsatile artery. When the inferior epigastric vessels cannot be identified, placing the trocar lateral to the rectus sheath, 6-7 centimeters lateral to the midline, should preclude the risk of injury to this vessel.

Once the sites are chosen, the skin is incised superficially with a #11 blade, just enough to accommodate the diameter of the trocar. A Kelly clamp is then inserted into the dermal defect, and the incision widened enough to allow subsequent dissection down to the rectus fascia. The point of the closed clamp should be laparoscopically visualized as it tents the rectus fascia.

The trocar is held so the index or middle finger extends down the sheath to act as a brake. The assistant can push on the contralateral abdominal wall to further elevate the site of insertion. Under continuous laparoscopic monitoring, the trocar is placed using a slow, twisting motion initially in a perpendicular fashion until it superficially penetrates the fascia. After fascial engagement, the direction of the sheath is directly altered in line with the planned surgical procedure. Failure to engage the fascia before angulation of the sheath risks inadvertent injury to abdominal wall vessels caused by sliding and then penetrating in a “Z” fashion. Particularly in obese patients, if the sheath is not properly redirected to the surgical field, the surgeon will have to put significant pressure on the sheath each time an instrument is inserted in order to redirect it to the surgical field. More importantly, the gross forces required to overcome this physical resistance significantly usurps deprives the surgeon of the sensitive touch necessary to palpate the tissues through laparoscopic instruments.
TECHNICAL ERGONOMICS

Instrument Grip
The elegance of surgical palpation and dissection is mediated by fine motor movements. Fundamental technical maneuvers such as grasping, elevating, spreading, rotating, and cutting are most deftly actuated at the hand and wrist. The surgeon’s grip on any laparoscopic instrument should ideally maximize the proprioceptive advantage of the fingers and palm. Isolating muscle and joint control to the distal upper extremity is accomplished by engaging the instrument with the fingers and palm, and controlling axial and rotational maneuvers at the wrist. Any conventional laparoscopic instrument can be “palmed” by learning to place the 4th finger paturally through one finger grip and leveraging the other with the thenar eminence. Otherwise, habitual engagement of both finger grips in a through-and-through manner virtually anneals the surgeon’s hand to the axis and handle of the laparoscopic instrument. Rotational maneuvers are consequently limited to larger joint and motor control at the elbow and shoulder girdle.

Table Height
Virtually every technical maneuver during laparoscopic surgery can be affected by the table height. It should always be at the level of the surgeon’s waist or lower. As the table rises above the waist of the surgeon, critical elements of control and finesse diminish incrementally. Proprioceptive feedback and motor control shift from the hand and wrist to the elbow, upper arm, and shoulder girdle. Insertion of the Veress needle or trocar generates greater thrust, and the adroitness of delicate surgical maneuvers is blunted.

Developing Equi-sidedness
The laparoscopic surgeon quickly becomes habituated to working primarily on the side of the patient opposite to his or her handedness. Spatial orientation and hand-eye referencing and coordination quickly condition to this configuration. Logically then to the surgeon’s chagrin, assisting or operating on the ‘opposite’ side of the patient can render the most schooled agility into a futile exercise of frustration and technical insecurity. The message should be self-evident. The laparoscopic surgeon should strive to be spatially and technically experienced from both sides of the table. This is most easily accomplished by consecutively alternating the side of surgery during diagnostic and sterilization procedures until the necessary comfort is realized. ‘Equi-sidedness’ recaptures surgical dignity, creates the bedrock of a proficient assistant, and removes any hesitation to perform a particular part of a laparoscopic procedure from either side of the table.


8. Childers JM, Brzechffa PR, Surwit EA. Laparoscopy using the left upper quadrant as the primary trocar site. Gynecol Oncol, 1993, 50:221.


Peritoneal Access

Andrew I. Brill, M.D.
Peritoneal Access

Reducing Risk
Fundamental Factors
FORCE IS THE ENEMY
large joint
large muscle
large nerve
reduce
Minimize Musculoskeletal Force

Ask for a Lift!

Drop the table!
The Umbilical Plate is *infra*-umbilical

midline incision
Abdominal Wall Elevation Methodologies

Tenacity = Control
Elevation = Countertension
Countertension = Proprioception

Manual

– Midline Suprapubic
– Bilateral Para-umbilical

or

Towel Clips

– Bilateral Para-umbilical
Veress Insertion Angles

thin

45°

90°
obese
The Umbilicus and Body Mass Index (BMI)
Peritoneal Access

AVOID

Premature Trendelenburg
Insufflation $> 20 \text{ mm Hg}$

Countertension
Volumetric
Does Trocar Type Affect Entry Force?

Tarnay and Munro  OBGYN 1999

Blunt Conical
Cutting-Dilating
Pyramidal

LB

0 5 10 15 20 25 30 35

ConMed Innerdyne

*
Does Trocar Type Affect Size of Fascial Defect?

Wound Area mm²

Tarnay and Munro Obstet Gynecol 1999

<table>
<thead>
<tr>
<th>Trocar Type</th>
<th>Wound Area</th>
<th>Wound Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyramidal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethicon</td>
<td>26.7</td>
<td>28.7</td>
</tr>
<tr>
<td>USSC</td>
<td>18.2</td>
<td></td>
</tr>
<tr>
<td>Cutting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dilating</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dexide</td>
<td>31.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Ethicon</td>
<td>28.7</td>
<td></td>
</tr>
<tr>
<td>Conical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ConMed</td>
<td>12.3</td>
<td></td>
</tr>
<tr>
<td>Innerdyne</td>
<td>10.0</td>
<td></td>
</tr>
</tbody>
</table>
Insertional Guideposts

Reusable = Proprioception

Disposable = Aural-ception
A Shielded Trocar

Does Not

Preclude Proper Technique
Remedy Soft Tissue Dystocia
DIRECT Trocar Insertion

Safety Predicates

- Secure abdominal wall elevation
- Sharp Instruments
- Knowledge of underlying anatomy
- Mobility of the bowel
- Controlled Entry
Maintain Midline Axis
THRUST AND INSPECT!

Evaluate Viscera and Retroperitoneum

BEFORE

Trendelenburg Positioning
No angle of insertion insures that the retroperitoneal vessels will be completely avoidable in all patients.
Dangers Below the Sacral Promontory
# 47 Injuries to Major Blood Vessels

## Sites of Injury - and - Frequency

*Soderstrom JAAGL 1997*

<table>
<thead>
<tr>
<th>Blood Vessel</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aorta</td>
<td>6</td>
</tr>
<tr>
<td>Vena Cava</td>
<td>5</td>
</tr>
<tr>
<td>Right Common Iliac</td>
<td>16</td>
</tr>
<tr>
<td>Left Common Iliac</td>
<td>5</td>
</tr>
<tr>
<td>Mesenteric A</td>
<td>4</td>
</tr>
<tr>
<td>Right Hypogastric</td>
<td>1</td>
</tr>
<tr>
<td>Right External Iliac</td>
<td>1</td>
</tr>
<tr>
<td>Left External Iliac</td>
<td>5</td>
</tr>
<tr>
<td>Several Vessels</td>
<td>2</td>
</tr>
<tr>
<td>Iliac Vessels</td>
<td>28</td>
</tr>
</tbody>
</table>
Foremost Reduction Strategy

Minimize Depth of Intraperitoneal Insertion
Alternate Insertion Sites

Abdominal Incisions

- Failed Conventional Strategies

- Morbid Obesity
No Incision is Immune
Any Abdominal Incision

Minimal peritoneal Mapping
Post-insufflation Peritoneal Mapping
Peritoneal Mapping

- **gas**
  - proceed
  - think adhesions or bowel

- **nothing**

- **stool**
  - thank God!
Open Laparoscopy

*Is it the answer?*
Safety of Open Laparoscopy

Predicated On

Predictable Anatomical Relationships

And

Direct Visualization of Peritoneum
Open Laparoscopy

Bowel Injury

Retroperitoneal Vascular Injury

DOES OCCUR!
Open Laparoscopy

Bowel Injury

is usually the mistake of choice!
Left Upper Quadrant Site - LUQ

empty stomach - no hepatosplenomegaly – no gastric surgery

Muscle Splitting
Peritoneal Tenting
3 Successive Releases
Altered Axis
Superior Epigastrics

Intercostal
8th intercostal space
Sup surface of 9th rib
Anterior axillary line
**Trendelenburg Position**

**Long Veress needle**

**Tenaculum on posterior cervix**

**Insert along midline axis**

**Remove under direct vision**

**Avoid when**

- cul-de-sac mass
- rectovaginal endometriosis
- fixed retroversion
- prior vaginal vault surgery
Trendlenburg position
Long Veress needle
Tenaculum on anterior cervix
Maintain midline insertion axis
Antevert uterus on fundal puncture
Remove under direct vision
Avoid when
multiple fibroids
fixed retroversion
high risk for adhesions to fundus
Access Decision Ladder

Umbilicus

LUQ

Open Laparoscopy

Cul-de-sac

Transuterine
Accessory Trocars
Major Vessels of Abdominal Wall

![Diagram of major vessels in the abdominal wall with labels SE, SCI, IE, and DCI for superficial and deep vessels.](image)
Superficial Epigastric Vessels
Identifying the Inferior Epigastric Vessels
Intentional Targeting
External and Internal Target Mismatch
Bump, Slide, and Perforate

Fascia
Ideal Entry

Fascial Engagement Before Angling into Pelvis
Inferior Epigastric Vessels

No Landmarks
Fascial Closure Guidelines

- Close fascial and peritoneal defects
- All defects > 10mm
- Defects > 5 mm
  - Lateral to rectus sheath
  - After significant tissue extraction
Intraperitoneal Sentinels

Depth Limiters

Incisional Girth

Proximity of Grip

Disengagement of Upper Body

Braking Ability

Abdominal Countertension

Perceiving the Moment of Entry
A sound knowledge of surgical anatomy is a requirement for performing laparoscopic procedures that are safe, efficient and effective. The gynecologic laparoscopist must have a working knowledge of the anterior abdominal wall, the superficial peritoneal landmarks within the pelvis, the structural anatomy of the pelvic retroperitoneum, and the endopelvic fascial support of the pelvic viscera. A knowledge of the anterior abdominal wall allows the laparoscopist to establish entry ports quickly and safely. Superficial peritoneal landmarks within the pelvis alert the operator to vital anatomic structures below the surface. A knowledge of the retroperitoneal structures facilitates dissection in these areas in an avascular manner without injuring the ureter or important nerves or causing hemorrhage. A knowledge of the endopelvic fascia and pelvic visceral support allows the laparoscopist to perform effective reparative procedures.

ANATOMY OF THE ANTERIOR ABDOMINAL WALL

The relevant landmarks on the anterior abdominal wall include the umbilicus, the anterior superior iliac spines, the pubic symphysis, and the pubic tubercles. Depending upon the body habitus and weight of the patient, the umbilicus may lie slightly above, at, or below the bifurcation of the aorta. In all patients, the left common iliac vein crosses the midline of the body approximately 3 to 6 cm. inferior to the level of the umbilicus. These anatomic relationships must always be in mind when placing a Veress needle or trocar through the umbilicus.\footnote{1,2,3,4} In the thinner patient, the surface of the anterior abdominal wall is significantly closer to the aorta and vena cava because of the decreased amount of adipose tissue in the wall itself, as well as in the fatty layers surrounding these great vessels.

In establishing lower lateral pelvic ports, the operator must avoid lacerating the inferior and superficial epigastric vessels.\footnote{4,5} The inferior epigastric artery and vein travel on the undersurface of the rectus abdominis muscle on its lateral third in the regions of the lower quadrants of the abdomen. These vessels originate from the external iliac vessels just before they exit the pelvis underneath the inguinal ligament. The inferior epigastric vessels are found just medial to the round ligament, as it exits through the internal inguinal ring. In most cases, their identification may be visually assured through the peritoneum within the pelvis. These vessels cannot be identified by transillumination of the anterior abdominal wall.

However, the superficial epigastric artery and vein may be found by transillumination, especially in the thinner patient. These vessels travel within the subcutaneous tissue of the anterior abdominal wall in variable locations lateral to the umbilicus. Vascular complications during laparoscopic procedures are commonly related to damage to these anterior abdominal wall vessels.\footnote{4,6,7,8,9} The majority of vascular injuries in the placement of lower abdominal ports can be avoided by placing the ports lateral to McBurney's point. This point is anatomically located on the abdominal skin as one-third the distance from the anterior superior iliac spine, along a line from the iliac spine to the umbilicus.

In the placement of lower central trocars, the operator must remember that the urachus is a midline structure running from the bladder to the umbilicus on the undersurface of the anterior abdominal wall. In rare circumstances, this conduit can remain partially patent and filled with urine.
Rogers Anatomy
Laceration in these cases can lead to postoperative extravasation of urine.\textsuperscript{10,11} The bladder itself can be lacerated, especially if the bladder has not been drained of urine.\textsuperscript{6,7,9,12}

The pubic tubercle is approximately 2 cm. lateral to the pubic symphysis on the body of the pubic bone. Lateral to the tubercle, along the superior pubic ramus, is the pectineal (Cooper's) ligament. The ilioinguinal nerve is located approximately 2 cm. lateral and superior to the pubic tubercle within the anterior abdominal wall. This nerve can be injured when placing sutures into the space of Retzius during a vaginal needle urethropexy and in some techniques of laparoscopic urethropexy. The operator must stay within 1 to 2 cm. of the pubic tubercle in order to avoid injuring the ilioinguinal nerve.\textsuperscript{13}

SUPERFICIAL PERITONEAL ANATOMY
All laparoscopic procedures need to begin with a routine inspection of the pelvis and upper abdomen. A clockwise evaluation should include inspection of the appendix, ascending colon, falciform ligament, liver, gallbladder, omentum, transverse colon, stomach, right and left hemidiaphragms, descending colon and sigmoid colon. The pulsations of the left ventricle of the heart can be observed through the left hemidiaphragm. The laparoscopist should note the location and severity of adhesions, inflammation, endometriosis externa, cul-de-sac fluid, tumors, cysts, peritoneal studding, or distortion of any pelvic or abdominal anatomy.

The peritoneum on the undersurface of the anterior abdominal wall covers three structures, thus creating "umbilical folds". Running from the dome of the bladder to the umbilicus is the median umbilical fold, underneath which is the obliterated urachus. Lateral to the median umbilical fold are the medial umbilical folds, under which are found the obliterated umbilical arteries. Dissection along the medial aspect of the obliterated umbilical artery toward the internal iliac artery in retroperitoneal dissection allows laparoscopists to locate the origin of the uterine artery. Just lateral to each medial umbilical fold is the lateral umbilical fold, which is formed by the peritoneum over the inferior epigastric artery and vein.

The uterosacral ligaments run from the cervix, around the rectum, to insert upon tough, presacral fascia over S2, S3 and S4. Anterior traction on the uterus places the uterosacral ligaments on tension, thus making them easier to identify. Near the cervix, the ureters are found just behind the peritoneum, just lateral to these ligaments.

THE URETER
Each ureter enters the pelvic cavity just superficial to the bifurcation of the common iliac artery and just deep to the ovarian vessels, which are in the infundibulopelvic ligament. This entrance is located at the level of the pelvic brim overlying the sacroiliac juncture. The ureter travels in its own endopelvic fascial capsule which is attached to the parietal peritoneum of the pelvic sidewall. In the patient placed in the dorsolithotomy position in preparation for laparoscopic surgery, the ureter courses almost horizontally and points towards the ischial spine. The ureter then passes just lateral to the uterosacral ligament, approximately 2 cm. medial to the ischial spine. This
Rogers Anatomy

area is just beneath the uterine artery, approximately 1.5 cm. to 2 cm. lateral to the side of the cervix. The ureter forms a "knee" turn at this point and travels medially and anteriorly to pass on the anterolateral aspect of the upper third of the vagina towards the bladder in its own "tunnel" of endopelvic fascia. The ureters enter the empty bladder approximately 5 cm. apart, course obliquely through the bladder wall for approximately 1.5 to 2 cm., and then enter the bladder at the corners of the trigone approximately 2.5 cm. apart.

The blood supply to the ureter originates from the various arteries along this path, including the ovarian, the internal iliac, the uterine, and the vesicals. The vascular supply travels in the longitudinal endopelvic fascial sleeve around the ureter. The ureter and this surrounding endopelvic fascial sleeve may be dissected together, away from the peritoneum and other structures during laparoscopic surgery without compromising its blood supply.

During any pelvic surgery, whether abdominal, laparoscopic, or vaginal, the ureter may be injured anywhere along its course.\textsuperscript{6,12,14,15,16} These injuries are generally mechanical or thermal in nature. Thermal injuries typically occur with laser energy or monopolar or bipolar electrical energy. Such injuries may damage the vascular sleeve that nourishes the ureter. Mechanical injuries can occur in a myriad of situations. These injuries may kink, occlude, or even transect the ureter. Staples, clips, sutures and scissors are the most common culprits. Table 1 outlines the common sites of ureteral injury.

THE ENDOPELVIC FASCIA AND PELVIC SUPPORT\textsuperscript{17}

The endopelvic fascia is visceral connective tissue found between the peritoneum and the parietal fascia covering the musculature of the pelvic basin. The pelvic basin is composed of a floor (the levator ani and coccygeus muscles), two sidewalls (the two obturator internus muscles), and a back wall (the piriformis muscles and sacrum). The front wall is the fused pubic bones. Microscopically, endopelvic fascia is a relatively loose, three-dimensional meshwork of collagen fibers, intermingled with varying amounts of elastin and smooth muscle. In contrast, the parietal fascia is predominantly collagen arranged in a regular, tough, unyielding structure. The endopelvic fascia forms sheets of visceral supporting tissue that fuse around visceral arteries and veins to form stronger sheaths. Also enveloped within these sheaths are visceral nerves, lymph nodes and channels, and varying amounts of adipose deposits.

There are two important purposes of the endopelvic fascia: 1. To function as flexible conduits and physical supports for the visceral pelvic vasculature, visceral nerves, and lymph tissue, and 2. To mechanically suspend the pelvic viscera - the bladder, the cervix and vagina, and the rectum - within the pelvis over the levator plate in order to secure pelvic visceral support. For instance, the cardinal ligaments not only surround and support the internal iliac vessels and uterine vessels, but also attach to the upper third of the vagina and cervix in order to position these structures horizontally over the levator plate for support.

An understanding of the endopelvic fascia - composition, purpose and location - facilitates retroperitoneal surgical dissections. Blunt probing parallel to the pelvic blood vessels reveals the sheaths of endopelvic fascia. Dissection in the proper plane between the endopelvic fascia and vessels allows the oncologic surgeon to safely perform lymphadenectomies. Likewise, reparative
pelvic procedures, such as urethropexies and paravaginal defect repairs, demand a familiar appreciation of the endopelvic fascia and normal supportive anatomy.

**PELVIC VASCULATURE**

The internal iliac artery travels parallel and just posterior to the ureter. The external iliac artery is several cm. anterior to it on the psoas muscle. The external and internal iliac arteries may then be followed superiorly to find the bifurcation of the common iliac artery at the pelvic brim overlying the sacroiliac joint. Through the peritoneum, the right common iliac artery may then be followed superiorly to find the bifurcation of the aorta, above the "presacral" space at approximately the fourth lumbar vertebra. The left common iliac artery is harder to identify because of the overlying mesentery of the sigmoid colon. The left common iliac vein is located just medial and inferior to the left common iliac artery in the "presacral" space. All these vessels are enveloped in sheaths of endopelvic fascia.

**THE LYMPH SYSTEM**

The lymphatic system is composed of multiple lymph nodes connected by an extensive network of intercommunicating capillaries and vessels. These structures are contained within the sheaths of endopelvic fascia which also envelop the pelvic vasculature. For descriptive purposes, the lymph system has been artificially divided into groups of lymph nodes described in relation to the nearest artery. Therefore, lymph nodes are found in the pelvis along the obturator artery, the external iliac artery, the internal iliac artery, the common iliac artery, and the middle sacral artery. In addition, lymph nodes have been described in the parametrium, surrounding the uterine vessels and their branches.

**VISCERAL NERVES**

The visceral nerves, likewise, are enveloped within the endopelvic fascia and areolar fat. They enter the pelvis from the superior hypogastric plexus found in the "presacral" space. These nerves are multiple and very fine, making them difficult to visualize, even with the laparoscope. Sometimes meticulous dissection within areolar fat may reveal the larger fibers.

The right and left hypogastric nerves then travel along with their internal iliac arteries and ureters to enter their respective inferior hypogastric plexuses. Each inferior hypogastric plexus contains multiple ganglia over an area of 3 x 5 cm. and is located just lateral to the uterosacral ligament in the pelvic sidewall. Many of these visceral nerves form the uterovaginal plexus (Frankenhauser's plexus), located around the uterine vessels and ureter just lateral to the cervix, and enter the uterus via the uterine vessels. Relatively few of these visceral nerves are found in the substance of the uterosacral ligament. This may be one reason why transection of the uterosacral ligaments has a high failure rate in alleviating visceral pelvic pain.

The visceral nerves are responsible for sympathetic and parasympathetic control of the glands, smooth muscles and vasculature of the pelvic organs - bladder and urethra; uterus and cervix, vagina; sigmoid colon, rectum, and anal canal. Also, these nerves transmit afferent sensations - such
as pain, pressure, distension - back to the spinal cord. Ablation of these visceral nerves in certain locations in the pelvis may somewhat relieve pelvic pain in a few, well selected cases. However in extensive ablation, such as in a radical hysterectomy, visceral dysfunction may result, such as bladder atony.

REGIONS AND SPACES WITHIN THE FEMALE PELVIS

The Paraaortic Region

The paraaortic region is the anatomic area from the renal vessels down to the bifurcation of the aorta in the posterior abdominal retroperitoneum. This also includes the lymph tissue around and lateral to the aorta and vena cava. The lateral borders are the ovarian vessels and ureters. Lymphadenectomy for the purposes of evaluating metastatic spread of pelvic cancer is the primary reason the gynecologist needs to be familiar with the paraaortic region.

For practical purposes, this region is divided into two areas. The lower paraaortic area is bounded by the bifurcation of the aorta up to the level of the inferior mesenteric artery, which is approximately 4 cm. superior to the bifurcation. Dissections for lymph tissue involving uterine, ovarian or cervical cancer involve this area. The infrarenal area (upper paraaortic area) goes from the level of the inferior mesenteric artery up to the left renal vein. The ovarian arteries exit the anterior aspect of the aorta in the midportion of this area. Lymph nodes here may be involved in the spread of ovarian cancer because of the lymphatic drainage from the ovary along the ovarian vessels. Therefore, lymph node sampling involving ovarian cancer involves this area.

In the paraaortic region, the ureter and ovarian vessels are found several cm. lateral to the aorta and vena cava. The abdominal ureter travels in its own visceral fascial sheath attached to the posterior parietal peritoneum. The right ovarian vein travels near the right ureter and empties into the vena cava. The left ovarian vein travels with the left ureter but empties into the left renal vein. These structures lie on the anterior surface of the psoas muscle, yet are ensheathed in visceral fascia, and along with the ureter, remain attached to the parietal peritoneum.

Elevation of the posterior abdominal parietal peritoneum lifts the ureter and ovarian vessels away from the psoas muscle. Therefore, blunt dissection in the proper plane allows the ureter and ovarian vessels to be easily separated from the psoas muscle. With this plane developed, the surgeon is assured that these structures are not in the field of paraaortic lymphadenectomy. The biggest concern on the left side is injury to the lumbar veins and arteries posteriorly. Anteriorly and medially, the major concern is avulsion of the ovarian arteries at their origin on the aorta. On the right lateral side, the ovarian vein can be injured as it enters the vena cava. The left renal vein is the major concern at the superior edge of the paraaortic region. Anomalous vessels should always be expected during these dissections. The inferior extension of this region is the "presacral" space.

"Presacral" Space

The "presacral" space is important to gynecologic surgeons when performing a "presacral" neurectomy or when removing presacral nodes. "Presacral" is a misnomer since this surgical area is just in front of the fourth and fifth lumbar vertebrae. The correct terminology is the lower "prelumbar" space. This space is bounded anteriorly by the parietal peritoneum and posteriorly by
Rogers Anatomy

the anterior longitudinal ligament and periosteum over the lowest two lumbar vertebrae and the
promontory of the sacrum. The middle sacral artery and a plexus of veins are attached superficial to
the anterior longitudinal ligament. The endopelvic fascia in this space envelopes fatty areolar tissue,
visceral nerves, and lymphatic tissue. There is no one "presacral" nerve but a multitude of finer
visceral nerves that course through, or even around this area over the common iliac vessels. The
"presacral" nerves are the fibers of the superior hypogastric plexus which is located here.

The right lateral boundary of the "presacral" space is the right common iliac artery and the
right ureter. The left lateral border is the left common iliac vein and left ureter, as well as the
inferior mesenteric artery and vein traversing through the mesentery of the sigmoid colon. All of
these structures must be identified when dissecting in this space. When performing a "presacral"
neurectomy, the operator must excise all fatty areolar tissue in this area since it contains the visceral
nerves that need to be ablated. Since these nerves may not travel in the central portion of the space
but may be more lateral toward the iliac arteries and veins, the surgeon must dissect as laterally as
possible without injuring the vital structures along its borders. Lateral and inferior dissection in the
"presacral" space leads to the structures entering the pelvis over the pelvic brim.

Pelvic Brim Region

The pelvic brim at the sacroiliac joint is a very important location for the entry of multiple
structures into the pelvic cavity and must be appreciated layer by layer. From the peritoneal surface,
working posteriorly to the sacroiliac juncture, the following structures are found crisscrossing over
one another: the peritoneum, the ovarian vessels in the infundibulopelvic ligament, the ureter, the
bifurcation of the common iliac artery, the common iliac vein, the medial edge of the psoas muscle,
the obturator nerve, and the parietal fascia just over the capsule of the sacroiliac joint. Just medial to
the obturator nerve is the lumbosacral trunk traveling from the lumbar plexus to the sacral plexus of
nerves. Because of the proximity of the ovarian vessels over the ureter at this level, the laparoscopic
operator must realize that ureteral injury can occur during ligation or coagulation of the
infundibulopelvic ligament. These structures then enter the pelvis and travel within the pelvic
sidewalls.

Pelvic Sidewall Region

Based on avascular planes, the pelvic sidewall consists of three surgical layers medial to
lateral. The first layer is the parietal peritoneum with the attached ureter in its own endopelvic
fascial sheath. When this peritoneum is incised and retracted medially, the ureter comes with it.

The second surgical layer consists of the internal iliac artery and vein and their visceral
anterior tributaries, all enveloped within the endopelvic fascia, which also envelopes the lymph
tissue, the visceral nerves, and fat deposits. Blunt dissection easily separates the first surgical layer
from the second surgical layer in an avascular manner. Contained within the second surgical layer
are the visceral branches of the internal iliac artery including the uterine, the superior vesical leading
to the obliterated umbilical, the inferior vesical, the vaginal and the middle rectal. During
retroperitoneal sidewall dissection, retraction of the obliterated umbilical artery places the superior
vesical artery on stretch, which points the operator to the internal iliac artery. Thus, this second
sidewall layer can be readily located.

The internal pudendal, the inferior gluteal, and the obturator arteries are the parietal branches of the internal iliac and promptly course into or along parietal fascia. During dissection in this second surgical layer, any of these arteries and veins may be occluded for the purposes of hemostasis without any adverse reactions. The rich collateral blood circulation in the pelvis permits this. However, to emphasize, the operator must not perform any procedures in this second surgical layer until the ureter, the external iliac vessels, and obturator nerve and vessels have been positively identified. The laparoscopic surgeon must take great care in avoiding any laceration or injury to the ureter, external iliac vessels, or obturator nerve.

The third surgical layer consists of the parietal fascia over the obturator internus muscle, with the obturator nerve, artery and vein allowed to remain along this muscle, though the obturator nerve may at times be retracted medially. Likewise, blunt dissection along the obturator internus fascia easily allows the second surgical layer of visceral arteries and veins to be retracted medially in an avascular manner. This is accomplished in dissections in the obturator space. In fact, this may be done down to the level of the ischial spine, where the obturator internus muscle tendon exits the pelvis through the lesser sciatic foramen. This knowledge is important in performing laparoscopic paravaginal defect repairs. During paravaginal repairs, this area is approached through the space of Retzius.

In another perspective from anterior to posterior, the pelvic sidewall may be easily viewed through the laparoscope through the peritoneal covering, especially on the right side. Anteriorly is found the psoas muscle. On its medial aspect is the external iliac artery with the external iliac vein just medial and posterior to it. Just underneath the external iliac vein is the bony ridge of the arcuate line of the ilium, which cannot be seen. Also not seen are the obturator nerve, artery and vein coursing underneath this ridge along the anterior border of the obturator internus muscle, traveling toward the obturator canal. However in the thinner patient, the ureter and the internal iliac artery are easily seen several cm. below the external iliac vein, traveling in parallel in an almost horizontal position. The ureter characteristically peristalses, while the internal iliac artery, just posterior to the ureter, characteristically pulsates with the rhythm of the heart.

**Base of Broad Ligament**

The cardinal ligament is found at the base of the broad ligament and contains the uterine artery traveling medially towards the lower uterine segment. Dissection of the pelvic sidewall naturally leads into this area. The surgical area located next to the lower uterine segment is known as the parametrium. That area located just lateral to the vagina is called the upper paracolpium. The uterine artery branches from the internal iliac artery, which then continues into the superior vesical artery and then into the obliterated umbilical artery. The origin of the uterine artery may be laparoscopically identified by dissecting along the medial border of the obliterated umbilical artery while working backwards toward the internal iliac artery. The medial offshoot is then identified as the uterine artery.

Passing just underneath and crossing the uterine artery here is the ureter as it travels into the ureteric "tunnel". This area is approximately 2 cm. lateral to the side of the cervix and is very near
the uterosacral ligament, which is just medial. Therefore, the ureter must be carefully identified during uterine artery ligation, any dissection in this area, uterosacral ligament transection, or suture ligation of the uterosacral ligaments. In fact, any transection of the uterosacral ligament causes subsequent scarring that may pull the ureter medially, closer to the cervix. This situation may make subsequent hysterectomy more likely to injure the ureter.

The space just anterior to the base of the cardinal ligament is the paravesical space. The space just posterior (towards the sacrum) is the pararectal space.

Paravesical Space/Obturator Space

The paravesical and obturator spaces are important during pelvic lymph node dissections, as well as reparative vaginal procedures. The paravesical space is a potential space beneath the peritoneum, bordered by the bladder and the bladder pillar medially, the fascia of the obturator internus muscle laterally, and the base of the cardinal ligament posteriorly. Anteriorly is the pubic bone. Contained laterally in this space is the obturator space. The obturator space is defined from the obliterated umbilical artery medially, to the fascia of the obturator internus muscle laterally, and from the external iliac vein above to the obturator nerve and vessels below. This space contains the obturator nerve, which needs to be identified during pelvic retroperitoneal dissection. As mentioned before, this nerve enters the true pelvis at the pelvic brim beneath the iliac veins, and travels on the anterior border of the obturator internus muscle to enter the obturator canal along with the obturator artery and vein. The obturator nerve is actually loosely covered with endopelvic fascia and fatty areolar tissue. During dissection in this area, the nerve is easily exposed by gently sweeping away this tissue.

To the reparative vaginal surgeon, these spaces are usually approached through the space of Retzius and are known as the lateral compartment of the retropubic space.

Pararectal Space

The pararectal space is important when performing radical hysterectomies. This space is easily developed by bluntly dissecting the ureter medially toward the rectum, and by bluntly dissecting posterior to the origin of the uterine artery. The anterior border of this triangular space is the base of the cardinal ligament. The medial border is the ureter dissected toward the rectum, while the lateral border is the internal iliac artery. The space also contains the uterosacral ligament, which is found on the anterior and lateral border as it travels posteriorly towards the sacrum.

Space of Retzius

The space of Retzius, or the retropubic space, is a potential avascular space with very vascular borders. The laparoscopist uses this space to perform retropubic urethropexies and paravaginal defect repairs. It consists of an anterior compartment and two lateral compartments. The anterior compartment is bounded by the pubic bone anteriorly, and the endopelvic fascial capsule that surrounds the bladder posteriorly. Contained within this endopelvic fascial capsule is the rich network of perivesical venous sinuses within deposits of areolar fat. Centrally over the urethra, just under the pubic arch, is the deep dorsal vein of the clitoris which feeds into these venous
Rogers Anatomy

channels. Therefore, dissection in the anterior compartment of the space of Retzius must not be directed centrally where these vessels may be lacerated.

The lateral compartment of the space of Retzius (same as the paravesical space) is bounded laterally by the obturator internus fascia and the obturator nerve, artery and vein, just beneath the bony arcuate ridge of the ilium. The posterior border (toward the sacrum) is the endopelvic fascial sheath around the internal iliac artery and vein and its anterior branches, as they course towards the ischial spine. The floor of this lateral compartment is formed by the pubocervical fascia as it inserts into the arcus tendineus fasciae pelvis (fascial white line).

The pubocervical fascia is the thickened anterior portion of the endopelvic fascial (fibromuscular) coat surrounding the vagina. When attached to both fascial white lines laterally and to the cervix posteriorly, the pubocervical fascia forms a horizontal platform underneath the bladder. This intact platform prevents cystoceles. Many cystoceles are caused by a detachment of the pubocervical fascia from one or both fascial white lines. This is known as a "paravaginal" defect. Reattachment of this fascial platform to the fascial white lines is felt to correct this type of cystocele.

The fascial white line (arcus tendineus fasciae pelvis) is a linear thickening of the levator ani fascia from the posterior aspect of the pubic bone in a straight line to the ischial spine. This may be readily seen during a laparoscopic paravaginal defect repair. In the standing female patient, the fascial white line is horizontally oriented, therefore, in the supine patient, this line travels in an almost vertical manner. Just above the level of the fascial white line may be seen the muscle white line (arcus tendineus levator ani) which is the origin of the levator ani muscles.

When performing a retropubic colposuspension through the laparoscope, the operator must remember that just underneath the external iliac vein and artery is the lateral continuation of the pectineal (Cooper's) ligament. These structures are hidden in areolar tissue and endopelvic fascia. Therefore, placement of sutures through the pectineal (Cooper's) ligament must stay within 3 to 4 cm. of the midline in order to avoid inadvertent laceration of these great vessels. Accessory obturator arteries and veins are often present. These vessels course from the inferior epigastric vessels and drape across the pectineal (Cooper's) ligament on their way to anastomose with the obturator vessels in the obturator canal. The surgeon must always look for them, since they are present in approximately 40% of patients.

The space of Retzius is easily opened laparoscopically. The peritoneum above the bladder is incised between the obliterated umbilical arteries (medial umbilical folds). The visualization afforded by the magnification of the laparoscope with its bright, directed light source is superb. With dissection in the proper plane, this space can be opened with essentially no blood loss. Excellent exposure to all relevant surgical anatomy is easily obtained. The positive pressure pneumoperitoneum also tamponades small venous bleeders, allowing hemostasis of these vessels to take place.

More inferiorly in the anterior compartment of the space of Retzius, the fatty areolar tissue must be dissected off the anterior vaginal wall to reveal the pubocervical fascia. This is done with a blunt instrument through a laparoscopic port and a finger in the vagina to stabilize the pubocervical fascia. In this area, sutures are placed 2 to 3 cm. lateral to the urethrovesical junction in performing a retropubic colposuspension. The urethrovesical junction is identified by the Foley bulb being
Rogers\hfill Anatomy

pulled down gently to the vesical neck. The distal two-thirds of the urethra is fused with the anterior vaginal wall. Therefore, sutures placed in the pubocervical fascia and attached to the pectineal (Cooper's) ligament allow significant and sure elevation of the urethrovessical junction close to but not against the pubic bone.

Vesicovaginal Space

The vesicovaginal space is a potential space between the anterior surface of the vagina (pubocervical fascia) and the posterior aspect of the bladder. This space is bordered laterally by the bladder "pillars" which allow for passage of vesical arteries, veins, lymph channels, and visceral nerves, along with the ureters. These structures pass just lateral to the lower uterine segment and cervix, and course on the anterolateral surface of the upper third of the vagina to enter the bladder.

When performing a hysterectomy, the surgeon must incise the uterovesical peritoneal fold. The potential vesicovaginal space is created by dissecting avascularly on the pubocervical fascia between the bladder and the cervix and vagina. The extent of dissection depends on the amount of vaginal margin required. Care must be taken not to injure the important structures in the more lateral bladder "pillars".

Rectovaginal Space

The rectovaginal space is bounded superiorly by the cul-de-sac peritoneum and the uterosacral ligaments, laterally by the iliococcygeus muscles, and inferiorly by the perineal body. Posterior is the endopelvic fascial capsule around the rectum, and anterior is the endopelvic fascial capsule around the vagina. The rectum may be easily and bluntly dissected away from the vagina, since the rectovaginal space is the potential space between these endopelvic fascial capsules around the rectum and vagina.

Within this space, and just behind the endopelvic fascial capsule of the vagina, is another endopelvic fascial structure called the rectovaginal septum. The rectovaginal septum attaches to the cul-de-sac peritoneum and the uterosacral ligaments, while inferiorly it attaches directly to the perineal body. Laterally, the rectovaginal septum attaches to the fascial white lines on the parietal fascia of the levator ani muscles. In the standing female patient, this structure forms an almost horizontal platform between the vagina and rectum and is felt to prevent rectoceles. Therefore, the reattachment of the rectovaginal septum to the above mentioned borders is important in the repair of rectoceles.

CONCLUSION

The three-dimensional field of pelvic anatomy, especially when viewed through the two-dimensional visual plane of the laparoscope, can be most difficult to master. Just as technical skills can be constantly improved through study and consistent practice, so can one's working knowledge of gynecologic surgical anatomy. Operating gynecologic laparoscopists must master the surgical anatomy in which they work. They must actively search for superficial landmarks within the pelvis and abdomen, and then identify the underlying structures. This knowledge of normal pelvic anatomy and anatomic relations assists the laparoscopist when faced with difficult dissections in
Rogers Anatomy
distorted anatomy due to pathologic conditions. Confidence in anatomic relationships allows the surgeon to perform procedures in a safe and timely manner. The alert gynecologist must always observe, question, study and persist in order to gain this sure working knowledge. Years are required for each individual to master all the information within this very complex and confusing subject.

END
Rogers Anatomy

TABLE 1
SITES OF URETERAL INJURY

1. The pelvic brim, underneath the infundibulo-pelvic ligament

2. Along the pelvic sidewall.

3. Just next to the uterosacral ligament.

4. Near the uterine artery.

5. On the anterolateral vaginal fornix, especially with vaginal surgery.
REFERENCES


Principles for the Safe Practice of Electrosurgery and Ultrasonic Surgery

Andrew I Brill, M.D.
Professor
Director of Gynecologic Endoscopy
University of Illinois at Chicago
Electricity is produced when valence electrons are freed from atoms of conductive materials. When these electrons are set in motion in the same direction an electric current (I) is produced that is measured in amperes. Opposite charges on the ends of the conductor cause the electrons to flow in one direction toward the positive terminal. The difference in potential between the positive and negative poles provides the electromotive force (voltage) to drive the current through the conductor.

Current that flows in one direction through a circuit is called direct current (DC). When alternating current (AC) flows through a circuit, the movement of electrons reverses direction at regular intervals which is expressed as cycles per second (hertz). Since the effects of current on the load are all that is important, the periodic reversal of current flow does not undue its work.

The amount of current that flows through a circuit is determined by the electromotive force across the circuit and the resistance that circuit provides the current. Resistance (R) is the difficulty that a material presents to the flow of electrons, and is measured in ohms. Resistance of biologic tissues varies depending upon the water content. It is very high in dry, calloused skin, moderate in lipid-rich adipose tissue, and very low in vascular tissue. Resistance for alternating current is expressed as impedance due to the induction of additional resistive phenomena (inductance) that include the effects of imploding electrostatic fields and the oppositional electromotive force of out-of-phase magnetic fields.

Current is directly proportional to the voltage and inversely proportional to the resistance, as expressed by Ohm’s Law:

\[ V = I \times R \]

Therefore, greater resistance requires greater voltage and, with a fixed resistance, greater voltage creates greater current. Logically then, when the switch of an electrical circuit is left open (i.e., when the resistance is infinite) the energy source will work at maximum voltage. This means that an electrosurgical generator produces the highest voltage across the electrode when it is activated remotely from the tissue surface without current flow.

Power is the rate of doing work and is expressed in watts (W). It represents the total quantity of electrons moved and the pressure gradient against which the movement occurred, as expressed by the equation:

\[ W = I \times V \]

Inserting Ohm’s Law:

\[ W = I^2 \times R \quad \text{and} \quad W = \frac{V^2}{R} \]

Therefore, power to tissue increases as a function of both the square of the voltage and the square of the current.
Alternating Current

Characteristics
Typical household power is supplied by an alternating current at a frequency of 60 cycles per second. Standard AM radio broadcast operates at a frequency range of 550 - 1600 kilohertz. Typical electrosurgical generators operate at 500 - 3,000 kilohertz. Hence, the common reference to both the electrosurgical generator and output current as radiofrequency.

Besides being characterized by a particular frequency, several different types of voltage measurements are used to describe alternating current. Peak voltage is the amount of voltage away from zero (either positive or negative). Peak-to-peak voltage is the amount of voltage from the negative peak to the positive peak (or twice the peak voltage). Since the average voltage would be zero, the term root mean square (RMS) voltage is used to describe the “average” effective voltage.

Faradic Effects
Alternating current is conducted through human tissues by ionic effects and may result in nerve depolarization and tetanic muscle stimulation (so-called faradic effects). These effects are maximal at 10-1000 hertz potentially causing muscular tetany and electrocution. Faradic effects begin to diminish above 2500 hertz and are usually absent above 300,000 hertz, when the net position of cellular ions change to a small degree due to the rapidity of the reversal of direction of the current. Modern electrosurgical generators operate above 500,000 hertz. Nevertheless, faradic effects can occur due to rectification, when some of the high frequency cycles are filtered out producing current of much lower frequency to the tissue. This may occur due to actual tissue filtering, or more commonly between the tissue and the active electrode during the sparking process (during fulguration and electrosection).

Waveforms
Although most contemporary electrosurgical generators have front panel controls that are labeled “cutting”, “blend”, and “coagulation”, these terms are not necessarily related to actual tissue effects. The variety of choices simply reflect different degrees of waveform modulation (damping) that can be incrementally produced by the generator’s solid state circuitry. Modulation is the periodic interruption of current flow. The “cutting mode” of the generator produces an unmodulated (undamped) pure sine wave with a relatively low peak-to-peak voltage. Switching to the “blend mode” simply modulates or interrupts the waveform; higher blend settings increase the degree of waveform modulation. The “coagulation mode” produces the most modulated waveform that correspondingly has the highest peak-to-peak voltage. Therefore, for equal power settings, increasing waveform modulation causes the peak-to-peak voltage to proportionally increase, i.e., energy must be conserved.

Capacitance
Capacitance is the property of an electrical circuit to store energy. Any device that creates capacitance is called a capacitor. A capacitor exists whenever two conductors that have different potentials are separated by an insulator. A difference of potential or voltage will exist between two conductors that have differing numbers of free electrons (an overall negative charge on the conductor with excess, and a positive charge on the electron-deficient conductor). Although separation by an insulator prevents the flow of electrons between these conductors, the potential
difference nevertheless creates an attraction or electrostatic force between them. This force results in an electric field and creates a reservoir of stored energy. When an alternating current flows through a circuit, the applied voltage and flow of current periodically changes direction. This means that a capacitor with alternating current is continuously “charged” in alternating directions. With each reversal of current flow, the energy of the stored electric field is discharged. Although no actual current flows through the capacitor, the charged current from capacitance completes the circuit and in essence conducts the alternating current. Since the amount of capacitance is directly proportional to the voltage, capacitance is greatest during open circuit activation.

The practical importance of capacitance is the inherent nature of all equipment carrying alternating current to induce stray capacitance, or leakage current on other conductors in the environment. Every conductor in the operating room is at risk to inherit a stray current by becoming capacitively coupled to the current of the active electrode. Potential conductors include surgeons and support staff, the patient’s jewelry, the operating table, an IV pole, an idle electrode, other electrical devices, surgical instruments, etc. These induced currents may lead to alternate current pathways back to ground. If the surface area of contact between the patient and the capacitively coupled object is small, the density of leakage current may be high enough to create thermal damage. Thus rings, earrings, and necklaces (even for Dennis Rodman) must be removed and the patient must be protected from naked contact with the stainless steel surface of the operating table.

All surgeons have experienced an unexpected shock across his or her gloved fingers while stabilizing a clamp in contact with a monopolar electrode. Although many such burns occur from the direct conduction of concentrated current through the hydrated rubber or a hole in the surgeon’s glove, these phenomena can also be caused by capacitive coupling. In the latter case, the electrified clamp and the surgeon’s fingers are two conductors with significantly different potentials. They are separated by a rubber glove which is a reasonably good insulator. Activation of the electrode, especially when activated before contacting the clamp (generating higher voltage), induces a coupled current on the surgeon’s fingers. If the area of contact between the fingers and the clamp is small, the current density will be high enough to generate a burn. Capacitance induced burns across the surgical glove can be eliminated by avoiding open circuit activation and cradling the surgical clamp with a large surface area.

"Grounding"
A fundamental understanding of grounding is necessary to practice monopolar electrosurgery with safety. A ground is some form of conductive connection between an electrical circuit and earth. Since the earth has an infinite capacity to absorb electrical charges, any electrically charged object connected to earth will equalize its potential difference with the earth.

Since monopolar electrosurgery applies high frequency alternating current to the patient with an active electrode, the electrode and patient become half of a capacitor and the grounded electrosurgical unit the other half. The insulator is the nonconducting environment. The use of a dispersive return electrode helps direct the current back to the generator by providing a route of lower impedance. This lowers the risk of alternate site burns caused by a concentration of current taking an aberrant pathway (e.g., EKG lead) to ground.
The risk of such alternate site burns is essentially eliminated by the presence of “isolated circuitry” in contemporary electrosurgical generators, where there is no direct connection between either the active electrode or dispersive electrode and ground. Furthermore, the circuitry design provides a mechanism for the generator to detect when a significant portion of the electrical current is no longer returning to the generator via the return electrode. When this exists the generator is automatically inactivated.

The Dispersive Electrode ("Return" Pad)
Although the dispersive electrode pad provides a pathway of low impedance for returning current to the generator, its misapplication can result in catastrophic thermal insult that is usually undetected at the time of injury. The rules for proper usage seek to minimize impedance while providing the greatest surface area for current return. Impedance is primarily minimized by choosing a site with adequate water content for conduction. Areas of skin with hyperkeratosis or hair and that overlie dense fat deposits (e.g., buttocks) should be avoided, while hair-free or shaved skin over larger muscles is preferred (e.g., upper thigh). Impedance is further reduced by choosing a site as close as possible to the active electrode.

The surface area of the return electrode must be large enough to permit the returning current to be widely dispersed. Tissue heating is intimately related to current density; current density is inversely related to the square of the surface area, and the rise in tissue temperature is directly proportional to the square of the current. Therefore, small decrements in the surface area between the dispersive pad and the skin can dramatically result in injurious thermal effects to the underlying tissues. Heat conduction by local blood flow should be maximized by placing the pad over non-dependent areas of larger muscles rather than areas where pressure may restrict perfusion (e.g., back and buttocks). A large surface area is guaranteed by a uniform and unalterable application. Areas with bony prominences or prone to movement on patient repositioning (again such as the back and buttocks) should be avoided. Since the edge of the dispersive electrode pad closest to the active electrode tends to concentrate the current, the longer edge of the pad should be placed toward the operative site.

Electrode Monitoring Systems
Contemporary electrosurgical generators are equipped with an automatic alarm and shutdown mechanism when the connection between the generator and the return electrode is not intact. However, this does not monitor the adequacy of contact between the surface of the grounding pad and the patient. Since the impedance to the flow of current via the dispersive electrode is quite small until most of the pad has peeled away, any drop in electrosurgical effectiveness should alarm the surgeon to check the application of the dispersive electrode.

Valleylab introduced a return electrode monitoring system (REM) that monitors the dispersive pad’s connection to the generator and the degree of contact with the patient. The dispersive pad is split into two functional halves; a small current is generated to flow through the first half, through the contiguous skin and tissue, and then via the other half to return to the generator which electronically monitors the local impedance. If the impedance is exceeded by separation from the skin, then the circuit is opened and an alarm is sounded. This innovation in dispersive pad technology completely eliminates the risk of thermal damage from an unpeeled electrode.
Tissue Effects Of Electrosurgery
By varying the rate and extent of the thermodynamic effects of electric current in biological tissue, high frequency electrosurgery is used to cut and/or coagulate. Although the efficiency of hemostasis is related to the depth of coagulation, it is of paramount importance that no more tissue suffers thermal damage than is absolutely needed. The art of electrosurgery is balancing between the need for absolute hemostasis and the least amount of deep coagulative necrosis.

Cutting (Electrosection)
The cutting of tissue occurs when there is sufficient voltage (at least 200V) between the electrode and the tissue to produce an electric arc which concentrates the current to specific points along the tissue surface. The open circuit creates an electric field that ionizes the intervening air. An avalanche of colliding and accelerating charged ions forms a plasma cloud that gives off light and sound as the ions pass to lower energy states to produce an electric arc. The extremely high current density delivered by the arc rapidly superheats the cellular water to temperatures greater than 600°C. Explosive cellular vaporization ensues secondary to the production of highly disruptive pressure (steam occupies 6 times the volume of liquid water) and acoustic forces. Arcing is then enhanced by an envelope of steam vapor that becomes instantly ionized. The use of the unmodulated cutting waveform helps sustain this envelope by producing an uninterrupted current that continuously maintains the same pathways for arc formation. Tissue contact eliminates the steam envelope and abolishes the cutting arc.

In general, the depth of coagulation along the cut edges increases with increasing voltage and length or intensity of the arcs. Therefore, an unmodulated cutting waveform produces a cut with the least amount of coagulative necrosis, while waveforms with greater modulation and higher peak-to-peak voltages result in larger zones of coagulation. Despite these parameters, the inevitable fluctuations in cutting rate, cutting depth, and the inhomogeneity of tissue makes these relationships less predictable due to their sum effect on the output current. Most conventional electrosurgical generators have a relatively high internal impedance, rendering output voltage dependent upon output current (Remember: V = I x R). Power output inevitably falls off as the tissue impedance increases. Furthermore, variable tissue resistance from cut to cut means that the depth of coagulation (i.e., output voltage) can also vary. Therefore, the amount of coagulative necrosis depends not only on the setting of the output power and the degree of waveform modulation, but also on the thickness of the active electrode, and the depth and rate of the cut.

When using conventional electrosurgical generators, the smallest depth of coagulation during electrosection is assured by employing the thinnest possible electrodes (i.e., edge rather than surface), using the unmodulated cutting waveform with low peak-to-peak voltage, and cutting as rapidly as possible using a single pass of the electrode. Deeper coagulation occurs when opposite parameters are applied.

A new breed of electrosurgical generators incorporate automatic control circuits to ensure that the intensity of the electric arcs and the output voltage are kept constant (constant voltage generator). This makes the depth of coagulation relatively independent of the cutting rate and
depth, as well as the magnitude of the output current. Thus, the distance of coagulation remains constant regardless of the magnitude of the output current. With this type of equipment, the operator can move the electrode as quickly or slowly as desired and at any angle without significantly affecting the depth of coagulation.

**Desiccation and Coagulation**

Contact of tissue with the surface of an active electrode leads to conduction of current with a low current density. Resistive heating is produced by the high frequency agitation of intracellular ionic polarities. As the tissue is slowly heated to temperatures above 50°C and maintained, irreversible cellular damage is initiated by deconfiguration of regulatory proteins followed by the denaturation of cellular proteins (white coagulation). Further heating to 100°C leads to complete evaporation of cellular water (desiccation), hemostasis secondary to the contraction of blood vessels and the surrounding tissues, and conversion of collagens to glucose that has an adhesive effect between the tissue and electrode. Temperatures above 200°C cause carbonization and charring.

Until the tissue reaches a temperature of 100°C and is completely desiccated, the rise in tissue temperature is directly proportional to the tissue resistance (degree of desiccation), time of current flow, and the square of the current density. Therefore, temperature change is more rapid at superficial depths, and evolves more gradually with larger surface electrodes.

As the tissue is progressively desiccated, current flow is moderated by a zone of electrically insulated steam vapor that forms between the electrode and tissue. The flow of current will eventually cease based on the output voltage. At lower voltages using the unmodulated cutting waveform, the coagulative process continues until the tissue is entirely dried out (soft coagulation). Continued application of current after completion of the evaporative phase leads to tissue adherence. Therefore, soft coagulation should ideally be terminated at the time of vapor formation.

At higher voltages when using modulated waveforms (especially with smaller electrodes), the vapor layer and desiccated tissue are punctured by electric arcs (forced coagulation) causing further coagulation until the coagulum is so thick it cannot be penetrated. Tissue becomes carbonized, sticky, and precariously unstable. This results in deeper coagulation at the expense of greater force, intense arcing, and increased temperature generation.

Monopolar electrosurgery is frequently employed during laparotomy to coagulate a clamped bleeder by using the clamp as a conduit for the activated pencil electrode. Since the sole intention is to weld the vessel lumen with minimal coagulative necrosis and lasting pedicle security, an unmodulated cutting waveform with lower peak-to-peak voltage should be used for coaptive desiccation.

During soft coagulation, the lower voltage of the cutting waveform heats the tissue more slowly so heat can flow into deeper tissue layers. Hence, it can be said that soft coagulation is more effective coagulation. Since the reduction of abnormal uterine bleeding after endometrial ablation is related to the degree of destruction of the basalis layer and superficial myometrium, it
can be formally argued that the unmodulated cutting waveform should be used for electrocoagulation of the endometrium.

In consideration of all the physical parameters that govern the behavior and effects of high frequency alternating electric current in biological tissue, both laparotomic and laparoscopic monopolar electrosurgery should be performed using an unmodulated cutting waveform for cutting and deep coagulation of tissue. Any electrode configured with both a flat surface and an edge (e.g., spatula electrode, electrosurgical scissors) can be used as an all-purpose electrosurgical tool with this waveform. The concentration of current at the edge or tip of the electrode provides arcing and hemostatic cutting of tissue. Blunt dissection, tissue traction, coaptation of small blood vessels, and contact coagulation can all be effectively accomplished using the flat surface.

Fulguration

Electric arcs generated by modulated waveforms with higher peak-to-peak voltages (fulguration) can superficially coagulate a broad surface of tissue with open vessels as large as 2 millimeters. Current modulation allows the steam envelope to dissipate between the interruption of sparks, causing the electric arcs to strike the tissue surface in a widely dispersed and random fashion thereby preventing tissue cutting. Although the higher voltage sparks are larger and create broad areas of charring (T° >500°C) and tissue destruction, current flow is limited to the superficial tissue layers due to rapid desiccation and the build-up of tissue resistance. Fulguration is relatively useless in the presence of a wet surgical field due to the diffusion of current by saline rich blood.

Teleologically then, the only selective indication for using the highly modulated coagulation waveform during monopolar electrosurgery is for the superficial coagulation of tissue along a large surface area. Exemplary needs for fulguration during laparotomy include hemorrhage in the subcutaneous tissue layers and atop the rectus muscles, and during laparoscopy along the myometrial bed after myomectomy, at the base of the ovarian cortex after cystectomy, and on Cooper’s ligament during urethropexy.

The Argon Beam Coagulator (ABC) uses the flow of Argon gas through an electrode device to form a comparatively longer bridge of electric arcs to the tissue. This gas is easier to ionize than air allowing the electric arcs to create a more uniform surface coagulation effect. The high flow of gas (4 liters/minute) displaces oxygen and nitrogen as well as pooled blood which focuses the effective surface area, and reduces the formation of smoke, carbonization, and tissue build-up on the tip of the electrode.

Problems Of Monopolar Electrosurgery At Laparoscopy

Contrary to the open surgical environment during laparotomy, the bulk of most instruments and nearly all surrounding intraabdominal structures are not visualized during any laparoscopic procedure. Furthermore, nearly all of the potential conductors during laparoscopic electrosurgery are also out of the surgeon’s field of view. Intended and unintended couriers of direct or induced currents include the abdominal wall, metallic trocar sheaths and instruments, the operating laparoscope, contiguous visceral tissues, and the active electrode (which is the only
part of the circuit under view!). It comes as no surprise that most accidental electrosurgical burns during laparoscopic surgery are undetected at the time of injury.

**Insulation Failure**

Insulation failure occurs secondary to breaks or holes in the insulation caused by physical abruption during use (such as during passage through an incompletely engaged trumpet cannula) or during normal reprocessing procedures. Completely intact insulation (especially on disposable instrumentation) can be breached by very high voltage (e.g., during open circuit activation or using a modulated coagulation waveform). Any break or breach in insulation may provide an alternate pathway for the flow of current. If the defective portion of insulation contacts tissue during electrode activation, an electric arc will bridge directly from the electrode through the defect to this tissue. Thermal damage will occur if the current density is high enough to significantly heat the tissue. Since these defects are usually out of the field of view, this type of injury usually proceeds undetected at the time of insult.

Insulation failure can be minimized by periodically inspecting the insulation covering of all laparoscopic electrodes (especially at the shoulder) for small cracks and defects. Disposable monopolar electrodes should not be reused. The risk of high voltage can be eliminated by using the unmodulated cutting waveform, and avoiding open circuit activation.

**Direct Coupling**

Direct coupling of current occurs when an activated electrode makes unintended contact with another metal object in the area of the surgical field. Since rectification (frequency demodulation) can occur during metal to metal sparking, sudden neuromuscular twitching may be its first telltale sign. Sparking between the electrode and a titanium staple can cause tremendous heat production by funneling of the current density. Accidental electrode contact with a suction-irrigator probe, the operating laparoscope, or a metal cannula creates an alternative pathway that is normally conducted up through a metal trocar to the abdominal wall and back to the dispersive electrode. However, if any of these devices are isolated from direct contact with the abdominal wall by an insulator (e.g., plastic cannula or self-retaining device), the current may take an alternative pathway through a point of contact with adjacent tissue. Again, if the current density is high, thermal damage may occur.

Direct coupling can be avoided by never activating the generator when the electrode is touching or in near proximity to another metal object in the surgical field.

**Capacitive Coupling**

Capacitive coupling is the induction of stray current to a surrounding conductor through the intact insulation of an active electrode. In fact, all of the necessary ingredients for the localized genesis of capacitance are provided by an activated monopolar electrode that is passed through a conductive sheath.

Two conductors of differing potentials, the active electrode and the metal sheath (e.g., trocar sheath, working channel of an operating laparoscope, irrigator-aspirator probe), are separated by the insulation of the electrode. On activation, up to 80% of the generator current is induced on the metal sheath by capacitance. Normally this stray current is safely returned to the dispersive
electrode by conduction through the large area of contact between the metal trocar sheath and the abdominal wall. The magnitude of capacitance is greater with higher voltage, smaller cannulas, and longer electrodes. Furthermore, the induced current will persist until the electrode is deactivated or it is conducted via an alternate pathway.

If the metal trocar sheath is attached to the abdominal wall by a nonconductive plastic device (e.g., hybrid trocar (metal/plastic) or plastic self-retaining screw device), the induced current becomes electrically isolated from the abdominal wall. Contact between the cannula and a visceral structure provides an alternate pathway for the stray current to discharge. Significant thermal damage will occur if the current density is sufficiently concentrated by a small area of contact. A similar phenomenon of capacitive coupling and isolation of current may occur during activation of an electrode placed through the working port of an operating laparoscope that is isolated from the abdominal wall by an all plastic cannula. In either case, the thermal injury is usually out of the surgeon’s field of view.

Capacitance is minimized by using an unmodulated cutting waveform and avoiding open circuit activation (i.e., minimizing voltage). An all metal system will suffice for the safe conduction of capacitively coupled current back to the dispersive electrode. Hybrid cannula systems (mixtures of plastic and metal) should not be used to house monopolar electrosurgical devices.

**Active Electrode Monitoring**

To assist in the elimination of the above risks during laparoscopic electrosurgery, Active Electrode Monitoring (AEM) was developed. This technology constantly monitors and actively shields the monopolar electrodes by using either an integrated sheath that is slid over the electrode or a completely integrated electrode. The shielding assembly is connected through the AEM to the return electrode and harmlessly conducts stray capacitive currents away from the metal capacitor. Deactivation automatically occurs when the capacitive current exceeds a predetermined safety level. The AEM also automatically shuts off the generator when a fault in insulation is detected. In both cases deactivation occurs **before** tissue injury.

**Bipolar Electrosurgery**

During monopolar electrosurgery, a high density of electrons leaves the active electrode and are ultimately dispersed over the broad surface of a return electrode pad. The current returns to the generator after the electrons pass through the patient via a myriad of variably conductive pathways.

Bipolar technology consolidates an active electrode and a return electrode into an electrosurgical instrument with two small poles (e.g., tines of forceps or blades of scissors). Rather than coursing through the patient, the flow of alternating current is symmetrically distributed through the tissue between the poles, reversing direction every 1/2 cycle. This eliminates the risk of capacitive coupling and alternate current pathways. Power requirements are significantly less than monopolar surgery due to the current concentration between the poles. **Therefore, an unmodulated cutting waveform with low peak-to-peak voltage is used during bipolar electrosurgery.** These factors intrinsically limit the thermal effects to desiccation and coagulation of tissue.
Bipolar electrosurgery is used for laparoscopic tubal sterilization by sequentially grasping and desiccating the midportion of the fallopian tube and adjacent mesosalpinx with the Kleppinger forceps. Failure of this method usually results from incomplete destruction of the tubal lumen with persistent viability of the endosalpinx. Complete desiccation is best ensured by including the vascular portion of the tube in the forceps, coagulating at least 3 centimeters of contiguous areas along the ampullary portion of the tube, and using an in-line ammeter to ensure that the tissue is completely desiccated. The power output from bipolar circuitry is normally calibrated to a smaller internal generator impedance than with comparable monopolar output (i.e., current drops at higher tissue impedance). Therefore, thorough desiccation of tissue is better ensured by higher current flow at higher tissue impedances. If a generator is used that is preset to produce maximum power at a low tissue impedance (i.e., typical monopolar outputs with modulated waveforms), then the electricity may fail to penetrate the inner layers of the fallopian tube. Since the power output would prematurely drop as the impedance rises secondary to desiccation of only the superficial layers, deeper layers of the fallopian tube may be spared from thermal damage.

The localization of current between the poles of the instrument during bipolar electrosurgery offers several distinct advantages. Thermal damage is generally limited to a discrete volume of tissue. The bipolar forceps can be used to coapt and thermally weld blood vessels. The concentrated current and small distance between the poles makes it possible to desiccate tissue that is immersed in fluid. The apparent disadvantages of this modality arise when open blood vessels are retracted or tissue pedicles are very thick.

Although the flow of current and primary thermal effects are restricted to the tissue between the poles, this does not remove the risk of thermal effects to tissue that is distant from the operative site. In fact, the net thermal effects are also governed by the physical parameters described during monopolar electrosurgery. The application of bipolar current leads to the gradual desiccation of the intervening tissue. The rate of tissue coagulation at any given power is moderated by the applied surface area of the poles, the thickness of the pedicle, the formation of a vapor layer between the poles and tissue, and the evanescing degree of tissue hydration. Impedance is maximal when the vapor phase is abolished as the tissue is completely desiccated. If the current is further applied and maintained more than several seconds, a secondary thermal bloom occurs to surrounding tissues from a correspondingly rapid rise in tissue temperature. Thus, tissues at some distance from the operative site may undergo subtle but irreversible thermal damage (e.g., the pelvic ureter during overzealous bipolar desiccation of the uterine artery).

During laparoscopic surgery other than tubal sterilization, the spread of thermal damage during bipolar desiccation should be minimized by terminating the flow of current at the end of the vapor phase, cooling the surrounding tissues with irrigating solution, applying current in a pulsatile rather than continuous fashion, avoiding the use of an in-line ammeter to determine the endpoint of desiccation, and securing vascular pedicles by using a stepwise process that alternates between partial desiccation and incremental cutting. The smallest depth of coagulative necrosis will occur when the sides or tips of a slightly open forceps are used to lightly “paint” the tissue surface for directed hemostasis.
HARMONIC SCALPEL

The harmonic scalpel is an ultrasonically activated laparoscopic device that provides mechanical energy to cut and coagulate tissue. A piezoelectric crystal housed in the handpiece vibrates the tip of a titanium blade at 55,500 times/second over a variable excursion of 50 to 100 µm. Energy is transmitted through tissue primarily in a linear fashion, parallel to lines of force. Hydrogen bonds that maintain the configuration of tissue proteins are ruptured, gradually leading to a denatured protein coagulum up to 2 mm without significant desiccation or charring. Mechanical vibration and cavitation produce tissue cutting. Steam bubbles that form as the vaporization threshold is reduced by local changes in atmospheric pressure concurrently separate tissue planes in front of the tip.

Available 5-mm blades include a hook electrode for cutting and coagulating and a ball tip for coagulating. A 10-mm laparoscopic coagulating shears (LCS) provides coaptive coagulation and cutting by securing tissue between a grooved plastic pad and a 15-mm multipurpose rotational blade with sharp, blunt, and flat surfaces. By employing various combinations of blade configurations, blade excursion, and tissue tension, specific tissue effects are created with this device. Operationally, cutting should be considered the obverse of coagulation. Cutting velocity is proportional to blade excursion, tissue traction, and blade sharpness, and inversely related to density and elasticity of tissue. Coagulation is inversely related to tissue tension, blade sharpness, blade excursion, and cutting speed. Thus, the fastest cutting occurs when tissue is placed on tension and firmly squeezed, lifted, or rotated with the sharp side of the blade set at maximum excursion. Effective coagulation is best accomplished by relaxing tissue tension, minimizing blade excursion, and using a blunt edge or flattened surface. Although a zone of coagulation of less than 1 mm is typically created by coaptive incision with the LCS, it remains proportional to blade excursion, application time, and applied pressure.
References


Energy Sources

Biophysics

Applications

Risk Reduction

Andrew I Brill MD
Reducing Risk during Electrosurgery
Electrosurgery is NOT Electrocautery
Resistance
VV
OO
LL
TT
AA
GG
EE

Current (I)
Resistance (R)
Voltage (V)

Terminology
Electrosurgery
Secondary Thermodynamic Change

Na⁺ Cl⁻
Cl⁻ Na⁺
Na⁺ Cl⁻
Electrosurgical Desiccation – Coagulation
- Resistive Heating -
Electrosurgical Cutting
- Cellular Vaporization -
What determines cutting or coagulation?

- Current Density
- Vaporization
- Desiccation

Temperature:
- 37°C
- 50°C
- 100°C
Current Density = Surface Area

W/cm² at 100W
**Current Density = Surface Area**

- Large surface area
  - Low current density
  - Desiccation

- Small surface area
  - High current density
  - Vaporization = Cutting
What Comes Out of The Box?
### Variations of Current and Voltage in Relation to Time

<table>
<thead>
<tr>
<th>PURE CUT</th>
<th>BLEND 1</th>
<th>BLEND 2</th>
<th>BLEND 3</th>
<th>COAG</th>
</tr>
</thead>
</table>

**Modulation**
CUT Waveform

High Current Density
Spark Formation → Cutting

> 200 Volts
Effects of Modulation on Cut Edges
COAG Waveform = Fulguration

Distributed Current Density
Contact Desiccation

CUT
Low voltage waveform
100% duty cycle

COAG
High voltage waveform
6% duty cycle

Gradual desiccation
Deep penetration

Rapid desiccation
Superficial penetration
Electrosurgical Desiccation – Coagulation
Tissue Effects of Waveforms

[Image of tissue effects with waveforms]
Loop Resection

Two Stage process

• Non-contact activation
  – Ionization of media
  – Spark formation

• Contact electrosurgical vaporization
  – Facilitation by steam formation
Monopolar Waveform and Cut Margins

Voltage = Lateral Zone of Coagulation
Monopolar Grooved Electrodes

Edge Density
Electrolyte-containing Solutions
**Conventional Monopolar Electrosurgery**

- In Normal Saline -

Current flows through saline following the path of least resistance to the return electrode.

*Saline Impedance = 25 Ω*  
*“active” electrode*

*Tissue Impedance = 100 Ω*  
*Tissue*
Bipolar Hysteroscopic Electrosurgery

- **SALINE ENVIRONMENT**
- **INSULATOR**
- **RETURN ELECTRODE**
- **ACTIVE ELECTRODE**
- **TISSUE**
- **CONTROLLED THERMAL EFFECT**
- **VAPOR POCKET**
- **CURRENT FLOW**
- **ACTIVE ELECTRODE**
VERSAPoint Bipolar Electrosurgery

Vapor Pocket: High impedance channels energy into tissue ($\geq 1000\Omega$)

Return Electrode

Active Electrode

Return current path (25$\Omega$)

Tissue Impedance = 100 $\Omega$
VERSAPoint Bipolar Electrodes

Spring  Twizzle  Ball
A Dangerous Combination

Monopolar Electrosurgery

Direct Coupling

Insulation Failure

Capacitive Coupling
Direct Coupling

Laparoscope View

Active Electrode

Bowel

Telescope with Camera

Metal Instrument
Insulation Failure

Abdominal Wall
Electrode Insulation Failure
Electrode Tip
Metal Trocar Cannula
Bowel
Laparoscope View
Capacitive Coupling
All Metal Trocar

with

Monopolar Electrode

INSTRUMENT/CANNULA CONFIGURATION
CREATING A CAPACITOR

Abdominal Wall

Conductor (Metal Cannula)

Conductor (Electrode Tip)

Insulator (Electrode Insulation)

Laparoscope View
All Plastic Trocar

with

Monopolar Electrode
Metal-Plastic Trocar
with
Monopolar Electrode

CAPACITIVELY COUPLED FAULT CONDITION
HYBRID SYSTEM

Capacitively Coupled Energy to Metal Cannula

Plastic Collar

Electrode Tip

Bowel
Metal-Plastic = Hybridized Trocar
Active Electrode Monitoring

Insulation Failure

Capacitive Coupling
Bipolar Electrosurgery
Ammeters and Tubal Coagulation
Invite Success

Ammeters and Desiccation
Invite Unwanted Thermal Injury
Bipolar Electrosurgical Thermal Effects

Terminate current at end of vapor phase
Bipolar Electrosurgery

Strategies to Limit Thermal Injury

- Terminate current at end of vapor phase
- Apply current in pulsatile fashion
- Irrigate surrounding tissues
- Liberally use relaxing incisions
- Avoid use of an in-line ammeter
- Use touch technique whenever possible
- Minimize pedicle volume
Thermal Injury

Recurrent Theme

Failure to attain anatomical freedom

before the application of energy
Bipolar Coaptive Desiccation

Hydrolavage for Clarity

Mechanically Coapt Bleeder

Mobilize Proximate Anatomy

Episodically Desiccate with Lavage
harmonic scalpel
Harmonic Scalpel

Ultrasonic

Energy
HARMONIC SCALPEL

ULTRASONIC ENERGY

MECHANICAL FORCES

TO

CUT AND COAGULATE
HARMONIC SCALPEL
PERIPHERAL ACTUATORS

HOOK & CURVED BLADE

COAGULATING SHEARS – LCS

BALL TIP
The Harmonic Scalpel

LCS – Laparoscopic Coagulating Shears

Levels

1-2-3-4-5

50-100μ

55,500 Hertz
Ultrasonic Cutting

Energy

Linear Propagation

1-2mm
Harmonic Scalpel

DENSITY

FRICTION

TIME

TISSUE EFFECTS
Harmonic Scalpel

Levels 1 - 5

Tissue Friction
HARMONIC SCALPEL

CUT vs COAGULATE

TECHNICAL MODERATORS

BLADE CONFIGURATION

Flat – Blunt - Sharp

BLADE EXCURSION

TISSUE TENSION

TIME
Ultrasonic Coaptive Coagulation

**GRASP LIGHTLY**

**RELEASE TENSION**

**FLATTER BLADE**

**LESSER EXCURSION**

**PATIENCE**
HARMONIC SCALPEL

CUTTING

IS THE OBVERSE OF

COAGULATION
Ultrasonic Coaptive Cutting

- Squeeze
- Lift
- Rotate
- Sharper Blade
- Greater Excursion
- Time
Cutting, Hemostasis and Tissue Fixation

Malcolm G. Munro, M.D.

Professor
Department of Obstetrics & Gynecology
UCLA School of Medicine
Los Angeles, California
Cutting and the maintenance or establishment of hemostasis are critical components of any surgical procedure. This is especially true in the performance of laparoscopically directed procedures, where, because of the visual, tactile and mechanical limitations, maintenance of hemostasis is preferable. Laparoscopic surgery has posed unique challenges that have resulted in a variety of creative solutions, each of which has particular advantages and disadvantages. Cutting can be achieved using (1) mechanical means, including linear cutters, (2) electricity, (3) laser energy, and (4) ultrasonic energy. The methods for maintaining or securing hemostasis could be generally classified as follows: (1) sutures, (2) clips, (3) linear staplers (4) energy sources, and (5) topical or injectable substances. The term “tissue fixation” is used because suture no longer is the only method available for attaching tissues together. Potential tissue fixation options include (1) suturing, (2) clips or staples and (3) tissue glue. Each of these methods will be reviewed considering the potential tactical applications.

A critical component of successful training in operative laparoscopy is the existence of a facility where the developing surgeon can practice knot tying and suturing skills. Most surgeons will remember that their facility with knots came largely from frequent repetitive practice on everything from shoelaces to leftover suture. If the only opportunity available for tying hand or instrument knots were in an inaccessible laboratory setting, skills in open surgery would not have progressed very far very fast. Added to the difficulty in learning laparoscopic techniques is the fact that they must be performed under the two dimensional guidance of a television monitor. Consequently, the trainee will benefit greatly from the existence of a secure facility where laparoscopic technique can be practiced under video guidance. The facility need not be elaborate but should include a pelvic trainer, a CCD camera and monitor, suture, needle drivers and other laparoscopic instruments necessary to create the simulation.

**CUTTING DEVICES**

**Mechanical**

Scissors remain extremely useful cutting instruments. However, “sharpness” is a prerequisite for effectiveness, a property that is difficult to apply to nondisposable instruments after repeated use. For this reason, disposable scissors are preferred. The advent of reusable/disposable instruments offers an opportunity for cost savings, as the instruments, like razor blades, are used until dull, then discarded. In a limited number of instances, a scalpel blade offers advantages. Scalpel handles designed for use through laparoscopic cannulas are now available.

**Electrical**

Electrosurgical electrodes that are narrow or pointed are capable of generating the high power or current densities necessary to vaporize or cut tissue. Continuous or modulated, unipolar, sine-wave outputs are used, depending upon the competing requirements for hemostasis and minimization of tissue necrosis, and the surgeon should be careful to operate in a non contact fashion, following, not leading the energy. Many novices confuse the
Munro Cutting, Hemostasis and Tissue Fixation

electrosurgical attachments on scissors as being designed to augment cutting. Instead such energy is used to provide a degree of desiccation-based hemostasis when cutting tissue laden with narrow caliber blood vessels. The same is true for bipolar scissors as well, which depend on mechanical means for cutting while using radiofrequency alternating current for the provision of a limited degree of hemostasis.

Lasers

Laser energy can be focused to vaporize and therefore cut tissue. The most efficient laser for cutting is the CO₂ laser, which has the drawback of requiring linear transmission, as it is difficult to bend the light while preserving power. Linear transmission is facilitated by a wave guide passed either through the operating channel of an operating laparoscope or an ancillary cannula. The Nd:YAG laser is also an effective cutting tool, especially when placed in contact, or near contact with tissue. It has the advantage of propagation along bendable quartz fibers but is associated with a greater degree of collateral thermal injury. Such injury may be desirable or unacceptable, depending upon the specific surgical requirements.

While experienced and well-trained surgeons can work effectively with such instruments, they still must frequently resort to the use of mechanical cutting. With these limitations, together with the expense of buying and maintaining laser instruments, it is difficult to justify widespread training in this area.

Ultrasound

The “Harmonic Scalpel”, (Ethicon EndoSurgery Inc., Cincinnati Ohio) exploits ultrasonic energy to create a cutting tool capable of use at laparoscopy. A pizo electrode, vibrating in the device handle, converts ultrasonic energy to mechanical energy by linear oscillation of the end-effector of the device, usually a blade, that can be used to cuts the tissue mechanically provided that it is inherently stable. In at least some tissue the mechanical cutting is aided by a vaporizing process termed “cavitation” (reduction of local atmospheric pressure allowing vaporization of intracellular water at body temperature). More flimsy or mobile tissue must be held and oriented in a way that inhibits transmission of the vibrations to the tissue itself thereby defeating the mechanical cutting effect. An end effector with a grasping design can replace the need to orient tissue and function as a pair of ultrasonic “scissors” depending upon the design of the “blades” ie a sharp or blunt edge. Such a design allows cutting to be accomplished simultaneously with the performance of hemostasis, including that of large vessels 3 or more millimeters in diameter. As a result, ultrasonic cutting tools are promising, but the ultimate value of these instruments, compared to conventional techniques, has yet to be determined.

Hybrid Devices

Linear Cutting-Stapling Devices

These devices have been used for more than a decade in open gastrointestinal surgery but have only relatively recently become available for laparoscopically directed procedures. The instruments maintain hemostasis by laying multiple parallel rows of tiny staples. They divide tissue by simultaneously pushing a sharp knife between the staple lines. The linear stapler-
Munro Cutting, Hemostasis and Tissue Fixation

cutters are available only in disposable formats in sizes ranging from 12 to 18 millimeters in diameter providing staple line lengths of approximately 30 to 60 millimeters. Depending upon the manufacturer the instruments may “fire” from four to eight cartridges containing staples of 1.0 or 1.5 mm depth. Recently, articulated linear cutter-staplers have added a degree of flexibility allowing the device to be applied to pedicles not previously feasible with the non-articulated variety.

In at least some circumstances the device reduces operating room time, but the cost, compared with alternatives such as suture and electrosurgical desiccation and coagulation is very high. Consequently, there are a limited number of potential gynecological applications of linear stapler-cutters, as they are currently designed and priced. There is potential value in securing the infundibulopelvic ligament for oophorectomy and the triple pedicles during the performance of laparoscopic hysterectomy. The uterine arteries may also be secured provided that the ureters are visualized. However, use in hysterectomy below the uterine arteries is often dangerous because of the diameter of the instrument and the anatomical location of the ureters.

When we use the device it is generally deployed through a midline port (umbilical or suprapubic cannula) to minimize cosmetic impact and to reduce the chances for dehiscence or hernia through additional large incisions.

Linear Cutting-Electrosurgical Desiccation Devices

These devices were designed as less expensive replacements for linear cutting-stapling devices (Everest Medical, Minneapolis MN; Circon Cabot). The concept is to use a grasping instrument to perform bipolar electrosurgical desiccation of a pedicle. Integrated into the design of the instrument is a deployable mechanical cutting blade, similar to that incorporated into the linear cutting-stapling devices. The pedicle is grasped, electrosurgically desiccated, and then transected with the mechanical blade that is activated by a trigger in the grip. The devices probably provide a degree of cost savings proportional to the number of “saved” stapling cartridges and offer the additional advantage of serving as grasping instruments, a feature not of practical value with linear cutting devices. In addition, the electrosurgical cutters are available in a 5 mm diameter design, much smaller than the 12 mm dimension of linear cutter-staplers. On the other hand, the recent availability of articulated linear cutting-stapling devices offers specific advantages in at least a number of tactical situations.

LAPAROSCOPIC SUTURING

While it was introduced in the United States over 20 years ago, laparoscopic suturing has only recently become accepted as a method for maintaining hemostasis or for achieving tissue fixation. The cost of materials is far less than is the case for clips or linear staplers, leaving operating time the main factor affecting cost effectiveness. Consequently, it is necessary to impart suturing skills that combine effectiveness with efficiency. In this segment, the emphasis will be on the efficient placement and tying of ligatures.
The two basic approaches to securing a ligature around a pedicle reflect of the site where the suture is tied. *Intracorporeal* knots are derivatives of the standard instrument-tied knot for they are formed and secured within the peritoneal cavity under laparoscopic direction. *Extracorporeal* knots are created outside the abdomen under direct vision, and are subsequently transferred into the peritoneal cavity by one of a variety of devices collectively known as knot manipulators. A hybrid knot is partially formed extracorporeally and then completed within the peritoneal cavity. Each of these types of knots can be formed from standard sutures or ligatures. However, there are available a number of commercially products that, at least in some instances, facilitate the efficiency of the suture-ligation process.

It is important to emphasize the proper placement of the cannulas for optimal knot typing and suturing. The ideal setup is to have the insertion points for the laparoscope and the two cannulas form an isosceles triangle with the site of knot tying located equidistant from the two needle drivers.

1. **Extracorporeal knots – half hitch**

   **Requirements:**
   - long ligature, at least 70 cm.
   - two laparoscopic ports, 5+ mm diameter.
   - loop or notched knot pusher
   - 5 millimeter appendix extractor (optional)
   - laparoscopic scissors
   - laparoscopic needle drivers X 2

   **Technique:**

   The pedicle is identified and stabilized. The appendix extractor is passed through the laparoscopic cannula. This step is not necessary if a cannula without valves is used. One end of the ligature is grasped with a laparoscopic needle driver or suitable grasper and passed through the port into the peritoneal cavity. The ligature is fed around the pedicle, usually with the aid of a second grasper or needle driver passed through another cannula. The ligature is then brought out through the first cannula using the original grasping device. While the suture is drawn out of the abdomen, there is simultaneous feeding of the long end into the peritoneal cavity to prevent sawing or pulling on the pedicle. When an adequate length of suture has been exteriorized, the knot can be hand tied.

   The most simple knot is a standard half hitch. A loop or horseshoe-shaped knot pusher is hooked over one strand near the knot and passed into the peritoneal cavity. The knot is advanced to the pedicle and tightened by simultaneously holding one end of the suture in each hand, applying traction with the knot manipulator distal to the pedicle. Additional hitches be added as required. The ends of the suture are then cut with scissors which can be
Munro Cutting, Hemostasis and Tissue Fixation

pass through either cannula.

2. Extracorporeal knots - Roeder and related knots

Requirements: - long ligature, at least 70 cm.
   - two laparoscopic ports, 5+ mm.diameter
   - notched knot manipulator
   - 5 mm appendix extractor
   - laparoscopic scissors
   - laparoscopic needle drivers X 2

The advantage of this knot and its many variations and relatives is that it is only necessary to form one knot for passage into the peritoneal cavity, a feature that may save time. The fact that this knot is secure with one transfer may make it preferable for vascular pedicles. Transfer of the knot into the peritoneal cavity requires a notched knot manipulator. The knot is most secure with gut, while the Westin modification is preferable for braided polygalactin or polyglycolic acid suture.

There exist a number of prepackaged products that include the suture, the knot manipulator and the appendix extractor. One variety is pre-tied with a Roeder knot to form a loop that may be passed over the pedicle. The knot is held at the desired spot with the end of the manipulator and then pulling on the externalized end of the suture tightens the loop. The loop configuration cannot be used unless the pedicle is open-ended, as for an appendix. Care must be taken to ensure that too much tissue is not included, as an included artery or vein may be inadequately compressed.

3. Intracorporeal knots – half hitch

Requirements: - short suture ligature, about 12 cm.
   - straight, ski-tipped or curved needle.
   - two laparoscopic ports, 5+ mm. dia.
   - 5 mm appendix extractor (optional)
   - laparoscopic scissors
   - laparoscopic needle drivers X 2

While intracorporeal knots are infrequently used for hemostasis more commonly they are used for tissue fixation or for anchoring a running stitch, such as for repairing a bladder laceration.

First the suture must be transferred into the peritoneal cavity. A needle driver may be passed through an appendix extractor to grasp the suture, drawing a straight, ski-tipped or small curved needle into the extractor lumen to allow passage into the peritoneal cavity. Larger curved needles may be passed into the peritoneal cavity by inserting the needle driver into the cannula after withdrawing it from the abdominal wall. The driver grasps the suture near the needle (about 3cm from the swage point) and is passed into the peritoneal cavity via the
Munro Cutting, Hemostasis and Tissue Fixation

Now empty incision. The cannula is now slid into place over the driver using it as a guide. For this method to be effective, the cannulas should be positioned lateral to the rectus muscles. Following placement of the suture, an instrument tie may be fashioned. Such ties are most easily achieved by grasping the tip of the needle with the needle driver in the left hand, using it to wrap the long end of the suture around the driver in the right hand. Then the right driver is used to grasp and pull the short end of the suture through the loop thereby completing the knot. Additional hitches are placed as necessary. For braided synthetic absorbable knots, a granny knot (two successive half hitches in the same direction) is the best way to start, for the knot may slide if necessary to provide more security.

4. Intracorporeal suturing – pre-tied loop

Requirements:
- short suture ligature, about 14 cm
- two laparoscopic ports, 5 mm diameter
- 5 millimeter appendix extractor
- laparoscopic scissors
- laparoscopic needle drivers X 2

A noose knot with an open loop and short tail is fashioned extracorporeally at the end of the suture after it has been cut to an appropriate length. Products with pre-tied knots are available (United States Surgical Corporation, Stamford CT). The needle and attached suture are then drawn into the appendix extractor in retrograde fashion using a laparoscopic needle driver and inserted into the peritoneal cavity. The needle is passed through the tissue and the suture pulled until the noose knot is reached. The needle and attached suture are then passed through the loop, which is tightened by grasping and pulling on the short tail with the other needle driver. The tissue edges are thereby approximated. If the knot is to be used for an interrupted stitch two additional throws should be made before the suture is cut. If, on the other hand, the loop knot is used as an anchor for a running stitch, no further throws are needed.

CLIPS and STAPLES

A clip is usually a small metal (most often titanium) V-shaped device specifically designed to provide or maintain hemostasis in vessels up to about 3 mm in diameter, depending upon the size of the clip. The device is passed into the peritoneal cavity via a 10 mm (or greater) cannula and deployed by a hand activated clamping action. The clips may be loaded singly into a non-disposable applicator, outside of the peritoneal cavity, or may be part of an automatically loading device, a feature that adds both convenience and expense. Clips are generally of greatest value (and safety) in the occlusion of skeletonized vessels where a well-defined pedicle can be established. Because they are prone to dislodge with significant manipulation they are not as appropriate in dissections where this might occur.

A staple is a fastening device, similar to a paper staple, that as a single entity may be used repeatedly to fasten tissue alone or via a sheet of mesh. The staples are generally produced in disposable 10 mm devices that automatically load twenty or more staples. In this format...
the staple has found greatest use in general surgery for the laparoscopically directed
treatment of inguinal or femoral hernias. To this point, such staples have found limited
gynecological use in experimental procedures such as retropubic bladder suspension and the
attachment of barriers designed to reduce or prevent the formation of post-operative
adhesions

ELECTROSURGICAL HEMOSTASIS

Electrosurgery, properly applied, is probably the most effective and cost efficient method for
obtaining hemostasis during laparoscopic procedures. Proper application requires a
thorough knowledge of the energy source as well as its bioeffects, control and safety. Most
of the complications and concerns about electrosurgery stem from ignorance or carelessness.
These issues are discussed elsewhere in this syllabus.

Medium Caliber Vessel Hemostasis

Vessels of several millimeters in diameter may be occluded by the process of
coagulation/desiccation secondary to the controlled application of radiofrequency electrical
current. The proximity of vital structures and the fact that patent blood vessels conduct heat
away from the site of energy transfer are factors to consider when electrosurgery is used for
this purpose. Bipolar systems are preferred, but in most instances unipolar technique is
equally effective and safe, provided that it is applied appropriately.

It is preferable to isolate the vessel as completely as practically possible for a length suitable
to allow for the creation of a pedicle on either side of the planned site of division. The
energy is best applied after occluding the vessel with a grasping forceps. When unipolar
technique is used, unless special monitoring shields are in place, care must be taken to ensure
that the coagulating forceps are not near to or in contact with bowel or other vital structures.
The current used should be low voltage continuous or non-dampened modulated. For
unipolar sources the duty cycle should be between 70% and 100%. The wattage used will
vary with the type and amount of tissue to be coagulated (tissue impedance) and the size and
shape of the electrode in contact with the pedicle. Typical effective bipolar outputs are in the
25 to 40 Watt range while for unipolar technique the range is usually from 40 to 70 Watts.
The current is applied until the vessel is seen to blanch and shrink. When bipolar energy is
used, a serial ammeter may be employed to determine when current flow ceases, a sign that
complete desiccation has occurred. It is possible that collateral thermal damage may be
minimized by intermittent activation or by copiously irrigating the site with a cool, low
viscosity fluid like saline or glycine. Following completion of the coagulation/ desiccation
process, the pedicle can be divided mechanically with scissors.

Small Vessel Hemostasis

A process similar to that described for medium sized vessels can occlude some small vessels.
However, it may be difficult to isolate such vessels so that they can be grasped with a
forceps. Visualization is enhanced with irrigation, and nonconductive low viscosity fluids
like glycine facilitate electrosurgical desiccation. In such instances, if the lumen of the
vessel is identified, it can be compressed with a narrow tipped unipolar electrode and
compressed. Non modulated energy can than be applied provided that the site is adequately separated from vital structures. The wattage employed will usually be significantly less than what is necessary for larger vessels, for smaller contact points will create a correspondingly higher current density at the same power.

Small vessel ooze is usually controllable with *fulguration*, a process that requires a larger unipolar electrode, higher voltage, modulated current and an absence of contact with the tissue. Fulguration will not work through blood so suction must be used to allow the current to impact on tissue. Provided that contact is not made with the tissue, the depth of coagulation rarely exceeds one millimeter. Depending on the electrosurgical unit, the shape of the electrode and the distance from tissue, power outputs of 60 to 100 Watts are usually used for fulguration.

**HEMOSTASIS USING OTHER ENERGY SOURCES**

The other available energy sources that may be used in acquiring hemostasis are laser and ultrasonic energy. Although medium sized vessels are difficult for either modality, small vessels may be occluded with either. A defocused CO₂ laser may be employed to superficially coagulate capillary ooze instead of electrosurgical fulguration. The ball attachment of the ultrasonic scalpel is also effective for the control of capillary bleeding. Discussion of the details of these modalities as well as the issues involved in the training of residents will be found elsewhere.

**MEDICAL and TOPICAL HEMOSTASIS**

There are medical methods by which small vessel and capillary bleeding may be prevented or controlled. Dilute vasopressin is effective at preventing or reducing the bleeding associated with antemesenteric salpingotomy for ectopic gestation.

A ten unit ampoule is diluted with at least 60 ml. of saline and drawn into a 10 ml syringe. The syringe may be attached to a special laparoscopic needle or to a 20 to 22 gage spinal needle. In the latter case, which is our preference, the needle is passed through the abdominal wall and is directed towards the ectopic gestation that is stabilized against the pelvic sidewall by a probe. It is our preference to inject the solution into the mesosalpinx below and beside the distended portion of the tube. To prevent inadvertent intravascular injection, the bevel should be held toward the laparoscope and the needle should be inserted into the mesosalpinx so that the tip can still be seen. “Tenting” the peritoneal surface with a pointed, toothed grasping forceps may facilitate this process. It is also important to inject a centimeter or more from the tube, where there is less edema and vascularity.

Another type of hemostatic agent is microfibrillar collagen, good for capillary ooze as well as for vessels up to two millimeters in diameter. This is a commercially produced product (Avitene) that is available in sheets or, more conveniently, a powder preloaded into a laparoscopic applicator. Avitene should be applied with pressure for at least two minutes.
CUTTING

- Mechanical
  - scissors

- Energy Sources
  - electricity
  - laser
  - ultrasonics

- Combination
  - mechanical cutting & stapling devices
  - mechanical cutting & tissue desiccation
Cutting, Hemostasis & Tissue Fastening

LOW POWER DENSITY
Desiccation/Coagulation

Rapid Heating to > 100

HIGH POWER DENSITY
Vaporization/Cutting

Slow Heating to 70-90
RF Electrosurgical Generators

Types of Output

- **CUT**
  - 50 WATTS

- **COAG**
  - 50 WATTS

- **RETURN**

- Fulguration - "Coag"
  - 6% duty cycle

- **Pure Cut**
  - 100% duty cycle
  - 500,000 Hz
  - 5800 volts p-p
  - 6% on - 94% off
  - Frequency 500,000 Hz

- **Blend 1**
  - 80% duty cycle
  - 80% on - 20% off
  - 500,000 Hz

- **Blend 2**
  - 66% duty cycle
  - 500,000 Hz

- **Blend 3**
  - 50% duty cycle
  - 50% on - 50% off
  - 500,000 Hz

- **Frequency**
  - 500,000 Hz

Cutting, Hemostasis & Tissue Fastening

M.G. Munro M.D.
Electrosurgical Vaporization

- Highest power density
  - generator output
  - electrode surface area
- Continuous or modulated current ("Cut" side)
- NON-Contact with tissue
- Cutting is the result of linear vaporization

Cutting, Hemostasis & Tissue Fastening
Tissue Thermal Injury:
Relationship to Duty Cycle
(Duty Cycle)

Cutting, Hemostasis & Tissue Fastening

Needle Electrode

M. G. Munro M.D.
CUTTING

- Mechanical
  - scissors

- Energy Sources
  - electricity
  - laser
  - ultrasonics
Ultrasonic

Cutting, Hemostasis & Tissue Fastening

Control Unit

End Effectors

Handle

Food Pedal
Cutting, Hemostasis & Tissue Fastening

Cutting Mechanism
1. Mechanical
2. Thermal
3. Cavitation

"Power" proportional to excursion of blade

55,000 Hz
Ultrasonics
Cutting, Hemostasis & Tissue Fastening

Cutting/ Hemostatic Performance
1. End effector surface shape
2. Power
3. Grip pressure
4. Tissue tension
CUTTING

- Mechanical
  - scissors

- Energy Sources
  - electricity
  - laser
  - ultrasonics

- Combination
  - mechanical cutting & stapling devices
  - mechanical cutting & tissue desiccation
Combination
Mechanical cutting & stapling

Cutting, Hemostasis & Tissue Fastening
Combination
Mechanical cutting & stapling

Cutting, Hemostasis & Tissue Fastening

Control of articulation
Combination
Mechanical cutting & desiccation

Cutting, Hemostasis & Tissue Fastening
Mechanical
- clips
- linear cutting / stapling devices

Energy Sources
- electricity: monopolar or bipolar
- laser
- ultrasound

Suture
Creating a Tissue Effect

Electrosurgery

Monopolar Instruments

Active Electrode

Zone of High Power Density

Dispersive Electrode

Zone of Low Power Density

Bipolar Instruments

Bipolar

ESU

2 Zones of High Power Density

Cutting, Hemostasis & Tissue Fastening

Cutting, Hemostasis & Tissue Fastening

50 Watts

M.G. Munro M.D.
RF Electrosurgical Generators

Voltage and Duty Cycle

\[ P = V \times I \]

**Pure Cut**

- **1200 volts p - p**
- **100% duty cycle**
- **Frequency 500,000 Hz**

**Blend 1**

- **4200 volts p - p**
- **6% duty cycle**
- **6% on - 94% off**
- **Frequency 500,000 Hz**

**Blend 2**

- **1500 volts p - p**
- **66% duty cycle**

**ESU**

- “CUT”
- “COAG”

**Fulguration - “Coag”**

- **50**
- **50**
- **80**
- **WATTS**

**M.G. Munro M.D.**
Tissue Thermal Injury

Electrode - Tissue Relationships

Ionization

Vaporization - near contact

Desiccation - contact

Fulguration - near contact

Cutting, Hemostasis & Tissue Fastening
Desiccation of Large Blood Vessels

I. Tissue compression

- Isolate
- Compress
- Desiccate with output wattage commensurate with the electrode surface area
- Consider the use of a serial ammeter
Compress First Before Desiccation of Large Blood Vessels

Flow from inadequately compressed vessel acts as a heat sink
Compress First Before Desiccation of Large Blood Vessels

Flow from inadequately compressed vessel acts as a heat sink

Cutting, Hemostasis & Tissue Fastening
Don't use "coagulation" (modulated, dampened, high voltage output)

High, modulated voltage current with low duty cycles (6%) result in unevenly desiccated tissue.
Desiccation of Large Blood Vessels 3/3

*Do* use "cut" (continuous low voltage) output

Low, continuous voltage currents result in slower but more even and complete desiccation.
SUTURING

- Equipment & supplies
- Technique

Cutting, Hemostasis & Tissue Fastening
SUTURING

Equipment & Supplies

- Needles
- Suture
- Needle drivers
- Knot manipulators
- Scissors

Cutting, Hemostasis & Tissue Fastening
SUTURING

Needles

- Shape
  - straight
  - ski
  - curved

- Diameter
**SUTURING**

Suture

- **Composition**
  - permanent vs absorbable
  - braided vs monofilament

- **Caliber**
  - large 1 to 2-O (extracorporeal)
  - fine 3-O to 7-O (intracorporeal)

- **Length**
  - 90-120 cm (extracorporeal)
  - 6-15 cm (intracorporeal)

- **Pre tied knots?**
SUTURING
Needle Drivers

- Handles
  - in line
  - offset

Cutting, Hemostasis & Tissue Fastening
SUTURING
Needle Drivers

- Handles
  - in line
  - offset

- End effectors
  - straight
  - curved
  - side-load

- Diameter
  - 3-10 mm

Cutting, Hemostasis & Tissue Fastening
SUTURING

Knot Manipulators

- Closed
- Open
- Slotted (for pre-tied loops)

Cutting, Hemostasis & Tissue Fastening
SUTURING  
Equipment & Supplies  
- Needles  
- Suture  
- Needle drivers  
- Knot manipulators  
- Scissors  

Cutting, Hemostasis & Tissue Fastening
SUTURING Technique

- Port placement
- Needle / ligature insertion
- Intracorporeal knotting
  - suture preparation
- Extracorporeal knotting
  - suture preparation
  - knot manipulators

Cutting, Hemostasis & Tissue Fastening
SUTURING

- Port & instrument positioning
  ➤ triangulation on the target

Cutting, Hemostasis & Tissue Fastening
SUTURING
Needle & Ligature Insertion
■ Direct insertion through cannula
SUTURING
Needle & Ligature Insertion

- Direct insertion through cannula

- Extracannular insertion

Cutting, Hemostasis & Tissue Fastening
SUTURING
Needle & Ligature Insertion

- Direct insertion through cannula

- Extracannular insertion

- Needle orientation

Cutting, Hemostasis & Tissue Fastening
SUTURING

Intracorporeal Tying

- Suture preparation
  - slip knot anchor

Cutting, Hemostasis & Tissue Fastening

Hassan Method
Morcellation and Tissue Extraction

William H. Parker, MD
Know Alternatives Approaches

- Different Anatomy
- Consistency of Tissue
- Volume of Tissue
- Equipment Does Not Work
Tissue Consistency

- Soft – Ectopic Pregnancy
- Fluid-filled – Ovarian Cyst
- Particulate – Dermoid Cyst
- Firm – Uterus (supracervical hyst)
- Hard – Calcified Myoma
Type of Tissue

- Benign
  - Sterile
  - Infectious
    - Contamination (bag)
- Suspicious for Malignancy
  - Seeding (bag)
- Malignant
  - Seeding (bag)
Tissue Capture

- **Graspers**
  - **Atraumatic** – 5 & 10 mm
    - Less damage, Less risk
    - Hold poorly
      - Fatigue
  - **Traumatic** – 5 & 10 mm
    - More damage, More risk
    - Hold well
Recommended Practices

- Observe Instrument Tips

- If not observed:
  - Keep tips closed
  - Do not move instrument

- Awareness
  - Sidewalls – vessels, nerves
  - Rectum
  - Bladder
Tissue Removal - Protected

- Via Cannula
  - Pull tissue into cannula
    - Open valve and extract
    - Remove tissue with cannula
Tissue Removal - Unprotected

- Pull tissue through port site
- Distends
  - Sterile
  - Benign
Port Site Metastasis

- Laparoscopy for diagnosis
  - Ovarian cancer, ascites
  - 7/43 (16%) had port site mets

- Laparoscopic treatment
  - Ovarian, uterine, cervical cancer
  - 1/105 (1%) had port site mets

Kruitwagen – 96 / Childers - 94
Appendectomy

- Ligate above incision site
- Appendix extractor, or
- Extract within cannula
- Copious irrigation
Endobags

- Mechanical devices
  - Easy to use
  - Weaker material
  - Risk - rupture and spread

- Cooper Sac
  - Strong – parachute material
  - Harder to use
Cooper Sac - Technique

- Insertion – roll up and push through cannula
- Open neck with graspers
- Fill with irrigating fluid to distend
- Insert tissue
- Close neck with string
Technique

- Grasp string and neck of bag
- Bring out abdominal wall
- Suction fluid to decompress
- Morcellate/extract tissue
  - Under direct vision to avoid perforation of bag
Extraction Sites

- Umbilicus – 10, 12 mm
  - Operating scope and grasper
  - Direct removal
    - Easy to extend and repair incision
    - 5 mm scope in lower port
  - Direct Morcellation
    - scalpel
Extraction Sites

- Lower ports
  - 5 mm
    - ectopic, simple cyst
  - 10 – 15 mm
    - Dermoid, myoma
    - Electromechanical morcellator
Extraction Sites

- Culdotomy
  - Advantages
    - Direct vision from above
    - Hold bowel away
    - Feed tissue from above
Extraction Sites

- Culdotomy
  - Disadvantages
    - Infection
    - Dyspareunia
    - Reposition patient
Morcellation

- Scalpel
  - Umbilicus
  - Lower port
  - Culdotomy
Morcellation

- Mechanical – Scissors, Semm Morcellator
  - Lower port
  - Under direct vision

- Disadvantages
  - Surgeon fatigue
  - Time consuming
  - Carpal tunnel syndrome
Morcellation

- Electromechanical
  - Lower ports - 15–20 mm
- Location
  - Anterior culdesac
    - Avoid bowel
  - Midplane
    - Avoid iliac vessels
Electromechanical

Technique
- Grasp tissue near edge
- PULL tissue into device
- Do not move device
- Observe cutting edge at all times
Electromechanical

- Technique
  - No undue resistance
    - Sudden loss of resistance – injury
  - Keep blade sharp
  - Surgeon operates pedal
Mechanisms of Adhesiogenesis

The peritoneum is comprised of an extremely delicate single layer of polygonal mesothelial cells. These cells are covered by microvilli which are easily damaged by placement of laparotomy packs, instrumentation or even dry conditions. Beneath this single cell layer is a rich connective tissue matrix composed of lymphatics, capillaries, collagen, reticular and elastic fibers. When the peritoneum is injured there is an acute inflammatory response of the underlying mesothelium, with release of histamine and kinins leading to edema and increased capillary permeability. Leakage of fibrin-rich serosanguineous exudate produces fibrin deposition in the area, of peritoneal injury. It should be noted that the fibrin deposition is entirely normal in all healing processes. When the tissue surrounding the site of injury is healthy, normal and well vascularized, plasminogen activator and subsequently plasmin are released. This leads to fibrinolysis and proper peritoneal healing without adhesions. However, if the tissue surrounding the area of peritoneal injury is ischemic or abnormal in any way, there is insufficient production of plasmin and fibrinolysis. This fibrin matrix subsequently becomes invaded by fibroblasts and capillaries leading to a permanent adhesion. Note that peritoneal repair occurs relatively quickly following injury. Fibrin is deposited almost immediately and is completely resorbed within seven days.

Reepithelialization occurs primarily from bottom to top, in contrast to the side-to-side healing that occurs when the skin is injured. Therefore, overzealous attempts to bring the edges of the peritoneum together by placing running locking sutures simply leads to added necrosis and ischemia over the suture line, with the formation of adhesions.

Postoperative pelvic adhesions may result from either the de novo formation of adhesions, or the reformation of previously existing adhesions.

Techniques for Adhesion Prevention

Adhesion prevention can involve technique, or the use of surgical adjuvants. Techniques for the prevention of postoperative adhesions include the use of microsurgery, the use of operative laparoscopy, and the use of early second-look laparoscopy. It is clear that the use of intra-abdominal lasers yields similar results to the use of electrosurgery, when meticulous microsurgical techniques are applied. It should be understood that the simple use of magnification does not make a microsurgeon or yield microsurgery.

The use of operative laparoscopy in place of laparotomy may also lead to a reduction in postoperative adhesions. Operative laparoscopy clearly eliminates the use of bowel packs and the resulting peritoneal abrasions. It may also reduce peritoneal dehydration by providing a closed pelvic environment. It provides continuous magnification up to 20 x, encouraging meticulous hemostasis,
A number of investigators have noted that early second-look laparoscopy leads to a reduction in postoperative pelvic adhesions. However, it is not clear that second-look laparoscopy leads to an improvement in the overall postoperative pregnancy rate. Trimbos-Kemper and colleagues noted that the cumulative pregnancy rate was the same whether early second-look laparoscopy was performed or not. However, they did note a significant reduction in the incidence of postoperative ectopic pregnancies.

**Adjuvants for Adhesion Prevention**

A number of adjuvants for the reduction of postoperative adhesions have been studied. The mechanisms by which these adjuvants work are numerous and include: the prevention of excessive fibrin accumulation (heparin, irrigation, dextran), increased fibrinolysis (proteases, heparin, and dextran), minimization of the inflammatory reaction (corticosteroids, antiprostaglandins, and antihistamines), reduction in fibroblast proliferation (corticosteroids), and separation of the peritoneal surfaces while they heal (barriers and dextran).

It should be noted that most studies of antiadhesive agents do not observe an improvement in the rate of mild to moderate adhesion formation, since the de novo adhesion formation rate offsets any beneficial effect that the antiadhesive adjuvant may have on these adhesions.

A randomized multicenter study of oxidized regenerated cellulose (Interceed), an absorbable adhesion barrier, was undertaken to determine its beneficial effect in the prevention of sidewall adhesion reformation. The initial report noted the experience with 74 patients, although this study has now been extended to 134 patients and the data remain unchanged. A non absorbable anti-adhesive barrier that is being studied is expanded polytetrafluoroethylene (PTFE, Gore-Tex). This barrier has been used for several years in vascular and cardiovascular surgery. It has been found to be nonreactive, nontoxic and antithrombogenic.
References


21. Sekiba K, The Obstetrics & Gynecology Adhesion Prevention Committee. Dept. Obstetrics & Gynecology, Okayama University Medical School, Okayama, Japan. Use of Interceed (TC7) absorbable adhesion barrier to reduce

22. The Surgical Membrane Study Group. University of Southern California School of Medicine. Los Angeles, CA; University of California-Davis, Davis, CA; The Johns Hopkins Hospital, Baltimore, MD; Women's Hospital of Texas and Baylor College of Medicine, Houston, TX. Prophylaxis of pelvic sidewall adhesions with Gore-Tex surgical membrane: A multicenter clinical investigation. Fertil Steril 1992; 57:921-3.

Hysteroscopy:
Preoperative
Patient and Uterine Preparation

Philip G. Brooks, M.D.
Cedars-Sinai Medical Center
Professor
Department of Obstetrics & Gynecology
UCLA School of Medicine
Hysteroscopy: Preoperative Patient and Uterine Preparation

Outline

• Preoperative
  – Standard informed consent
  – Laparoscopy consent
  – Pre-medication and/or mechanical
    • Anti-vagal
    • Endometrial thinning

• Intraoperative
  – Long-acting analgesic
  – Vasopressin
Hysteroscopy: Preoperative Patient and Uterine Preparation

When Hysteroscopy + Laparoscopy? 1/2

- Wise to get consent always
- Lysis of intrauterine adhesions
  - always if dense or total obstruction
  - rarely if focal
- Septoplasty (unless under U/S monitoring)
- Ablation
  - rarely
  - beginners (?)
Hysteroscopy: Preoperative 
Patient and Uterine Preparation

When Hysteroscopy + Laparoscopy? 2/2

• Hysteroscopic Myomectomy
  – rarely if pedunculated
  – occasionally if intramural

• For Uterine Perforation
  – Always if done with energy source
  – Lateral perforation
  – Continued bleeding

• For Tubal Sterilization when desired
  – Do tubal sterilization after ablation
Hysteroscopy: Preoperative
Patient and Uterine Preparation

Premedication

• Anti-vagal
  – especially for office procedures
  – Atropine 0.2 mg subcutaneously
Premedication and Mechanical

- Endometrial Thinning
  - Cycle timing: early proliferative phase
  - Mechanical: vigorous curettage
  - Hormonal Preparation:
    - Progestins
    - Danocrine
    - GnRH agonists
Pre-operative Endometrial Thinning Agents Before Hysteroscopic Surgery for Heavy Menstrual Bleeding (Cochrane Review)

• Eight RCTs met the inclusion criteria for the review
  – 4 compared GnRH analog (goserelin) to placebo
  – 3 compared GnRH analog (goserelin) to danazol
  – 1 compared GnRH analog (triptorelin) progestogens, danazol and no treatment

• Conclusions
  – “Endometrial thinning prior to hysteroscopic surgery for menorrhagia improves both the operating conditions for the surgeon and short-term postoperative outcome…the effect of these agents on longer term post-operative outcomes…has not been considered”
Hormonal Inhibition of the Endometrium for Resectoscope Endometrial Ablation

Philip G. Brooks, M.D.
Scott P. Serden, M.D.
and
Irene Davos, M.D.

Departments of Obstetrics and Gynecology and Pathology
Cedars-Sinai Medical Center
Los Angeles, California
Hormonal Inhibition of the Endometrium for Resectoscopic Endometrial Ablation

• Materials & Methods
  – 25 patients with D.U.B.
  – Ablation performed with Storz GYN resectoscope, wire loop, ValleyLab Force-2 ESU, 110 Watt cutting current.

• Preoperative
Hormonal Inhibition of the Endometrium for Resectoscopic Endometrial Ablation

**Preoperative Treatment**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Duration Preoperatively</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Treatment</td>
<td></td>
</tr>
<tr>
<td>MPA 200 mg IM</td>
<td>6-8 weeks</td>
</tr>
<tr>
<td>NET-Acetate 5mg P.O.</td>
<td>&gt; 5 weeks</td>
</tr>
<tr>
<td>Danazol 600 mg P.O.</td>
<td>&gt; 5 weeks</td>
</tr>
<tr>
<td>Leuprolide Depot 7.5 mg IM</td>
<td>day 21-24 4-5 weeks</td>
</tr>
</tbody>
</table>
Untreated Endometrium
Progestin
Danazol
GnRH Analog (Leuprolide)
GnRH Agonist
## Comparison of Methods for Preparation Prior to Ablation

**N=172 (Feb 1987-October 1992)**

### Menstrual Pattern After Ablation

<table>
<thead>
<tr>
<th>Group</th>
<th>Amenorrhea N (%)</th>
<th>Hypomenorrhea N (%)</th>
<th>Eumenorrhea N (%)</th>
<th>Persistent Menorrhagia N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>U Group</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No pre Tx</td>
<td>24 (47)</td>
<td>21 (41)</td>
<td>2 (4)</td>
<td>4 (8)</td>
</tr>
<tr>
<td><strong>P Group</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Progestin</td>
<td>6 (55)</td>
<td>2 (18)</td>
<td>1 (9)</td>
<td>2 (18)</td>
</tr>
<tr>
<td><strong>D Group</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Danazol</td>
<td>12 (46)</td>
<td>11 (42)</td>
<td>2 (8)</td>
<td>1 (4)</td>
</tr>
<tr>
<td><strong>L Group</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leuprolide</td>
<td>57 (68)</td>
<td>20 (24)</td>
<td>5 (6)</td>
<td>2 (2)</td>
</tr>
</tbody>
</table>
Conclusions

Preparing the for ablation with GnRH agonist:

- Reduces the thickness of the lining
- Reduces the vascularity of the uterus, reducing blood loss during the procedure and possibly reducing intravasation.
- Enhances ease of the procedure.
- Improves long-term results with increased amenorrhea rates and decreased failure rates
Hysteroscopy: Preoperative
Patient and Uterine Preparation

Intraoperative Preparation

• Analgesic:
  – Marcaine 0.25% or Carbocaine 1%
  – Inject directly into cervical stroma 2 ml, 3 areas
  – Other approaches

• Vasopressin
  – 5 units in 20 ml of above analgesic
  – reduces bleeding and intravasation
  – reduces force required to dilate cervix
The Use of Pitressin for Operative Hysteroscopy

- Randomized, placebo-controlled, double blind study of 64 patients undergoing resectoscopic surgery (ablations, myomectomies, etc.) with 3% Sorbitol distention
- Pitressin diluted 20 units in 50 ml. Saline
- Intracervical injection of up to 4 ml each side (equals 3 to 4 units of pitressin totally)
- Blood loss was estimated, fluid deficit calculated
The Use of Pitressin for Operative Hysteroscopy

• Randomized
• Blood loss was significantly reduced in the Pitressin group
• Intravasation was significantly reduced in the Pitressin group; patients receiving Pitressin had 1/3 the risk of intravasation of those in the placebo group.
Complications during hysteroscopic surgery are not common and many large series report no serious problems. However, when community wide experience is reviewed, complication rates exceed those published by the experts. It is difficult to discuss the true frequency of complications since many go unreported, or, if reported, are included in case reports without reference to the number of similar cases done without difficulty.

Virtually all hysteroscopic complications occur during operative hysteroscopy rather than diagnostic cases.

Complications associated with distending media

The uterus must be distended in order to provide a cavity to perform panoramic hysteroscopy. The intrauterine pressure created by distension must be high enough to prevent clouding of the distending media by bleeding from the endometrium and myometrium. Ideally only enough intrauterine pressure would be used to equal the vascular pressure. In such an ideal scenario, there would be no bleeding into the uterine cavity or intravasation of the distending media into the vascular system. Unfortunately, the vascular pressure and the intrauterine pressure are not constant. If the intrauterine pressure is less, blood will obscure good visualization. Therefore, the intrauterine pressure must always be equal to and generally above the intravascular pressure. Since some open vessels are always encountered, this means that there will always be some intravasation of distending media into the vascular system.

There are four factors which must be taken into account when discussing intravasation of distending media. They are: 1) the intrauterine pressure; 2) the number and size of vascular openings; 3) the length of the procedure; and 4) the intake and output.

Intrauterine pressure - The single most important factor that the surgeon has control over is the pressure used to distend the uterine cavity. Seventy-five centimeters of mercury pressure is generally sufficient. The actual intrauterine pressure will always be less since fluid lost from the uterine cavity through leakage or through the outflow port of the hysteroscope is not instantaneously replaced. It must flow from its source into the uterine cavity through tubing and the hysteroscope both of which after resistance to flow. Higher pressures do not provide for better visualization and usually increase intravasation by increasing the rate of flow from the uterine cavity into the vascular system.

If gravity is used as a distending media, the column of fluid should be one meter above the level of the uterus to provide 75 mm Hg of pressure. If a drip chamber is used that is the height above the uterus only wide base (urological) tubing should be used. Since these variables may not be understood by supporting staff, a variable pressure pump system is frequently preferred by surgeons.

The number and size of vascular openings - There are more vascular channels open during operative hysteroscopy than diagnostic hysteroscopy. However, there are open vascular channels under both circumstances. It is those procedures where the deep myometrial vessels are encountered such as the removal of the intramural portion of the fibroid or the transection of
difficult uterine adhesions which opens the most and the largest vascular channels. A partial perforation of the uterus or tear in the lower uterine segment during dilation may also be an unexpected source of intravasation. While the surgeon has little control over the number or size of these open vascular channels, those procedures where intravasation is potentially high can and should be anticipated.

Length of procedure - Since some intravasation will occur in every hysteroscopic case, the amount is dependent not only upon the amount of pressure used to drive distending media into the vascular system and the number and size of vascular channels open, but also the length of the procedure. The surgeon has some control over this factor. Cases should be accomplished as quickly as is safely possible thus limiting the amount of fluid intravasated. Finally, since intravasation will occur in essentially all cases, the single most important thing to consider is the accurate calculation of intake and output. Newer systems which actually measure fluid by weight will allow the hysteroscopist to know precisely the amount of fluid that has been intravasated. Measuring volumes is inaccurate since most containers are overfilled by as much as 10%.

Intake and Output

A fluid management protocol should exist in all operating rooms. Absolute guidelines for fluid management are too arbitrary using maximum procedure time or fluid loss as criteria have significant disadvantages. There is still a place for clinical judgment. However, without accurately knowing the amount of fluid loss in real time the surgeon cannot implement good clinical judgment. A fluid monitoring system eliminates the human factor, provides constant monitoring and alarms for acceptable predetermined fluid loss.

Gaseous Embolization

When carbon dioxide is used as a distending media intravasation will occur for all the same reasons as when a liquid media is used. Because of the body’s ability to rapidly exhale intravasated carbon dioxide, this is not a problem unless excessive flow rates are used.

Gas is also formed within the uterine cavity during operative procedures using Nd:Yag or electrical surgical energy. There is no evidence of show that this can be a significant problem to patients but good hysteroscopic surgical principles which include primarily the rapid clearing of these bubbles is important. Of greater concern is the potential risk of embolization of air into the vascular system with its significant sequella. Care in purging the hysteroscopic inflow tubing is critical as is keeping the patient flat on the operative table. Reverse Trendelenburg which potentially opens venous sinuses in the uterus, above the level of the heart is the primary mechanism for these serious problems.
Hemorrhaging

Serious bleeding is seldom a problem during hysteroscopic surgery since when the uterus contracts, the vascular supply is essentially occluded similarly to what occurs in the post partum uterus. Avoidance of cutting deep into the myometrium especially in the lateral lower segment where the large branches of the uterine artery reside will prevent the occurrence of this problem. When excessive bleeding does occur, the use of a diluted pitressin solution or very rarely a uterine balloon can be used.

Perforation of the Uterus

This problem may occur during cervical dilatation, insertion of the hysteroscope or during an operative procedure. Introduction of the hysteroscope under direct vision should reduce the risk at that time to virtually zero. Perforation during the course of an operative hysteroscopy can be reduced if the operator insists on adequate visualization. Continuous flow hysteroscopic equipment should be able to assure good visualization in all cases. The hysteroscopic surgeon should be oriented within the uterine cavity and have achieved good visualization before undertaking any surgical procedure. Difficult and severe cases of intrauterine adhesions carry a high risk of uterine perforation and in these cases the concomitant use of ultrasound or laparoscopy may be beneficial.

The energy sources available to the hysteroscopic surgeon are mechanical, laser, and electrical (unipolar and bipolar). All have a place in hysteroscopic surgery. However, the hysteroscopic surgeon must recognize that the Nd:Yag laser by virtue of its physics will deeply penetrate as well as spread within tissue thus increasing the potential risks of damaging unwanted tissue.

Unipolar electrical energy requires non-electrolyte solutions which increase the risks when excessive intravasation occurs as well as the damage to surrounding structures as it spreads on its return to the ground plate. Bipolar instrumentation will avoid these risks. Mechanical energy although limited by the small size of the instrumentation has the advantage of using a physiological solution and no damage beyond the end of the instrumentation which can always be kept in view of the hysteroscopist.
References
4. Loffer FD. The need to monitor intrauterine pressure - myth or necessity? J Am Assoc Gynecol Laparosc 2:1-2, 1994
Diagnostic Hysteroscopy
Hysteroscopy and Saline Infusion Sonography: Managing Menstrual Disorders

Linda D. Bradley MD
Department of Gynecology and Obstetrics
Director of Hysteroscopic Services
Cleveland Clinic Foundation
Cleveland Ohio
216 444-3435
216 444-8551 Fax
bradlel@ccf.org
Bradley Diagnostic Hysteroscopy

Introduction

Each year there are an approximately 33 million office visits to evaluate abnormal uterine bleeding. The prevalence of menstrual complaints increases each decade after age 20 years, and peaks in the mid 40's to 50's. Increasingly, as women live longer and electively utilize hormone replacement therapy (HRT), the prevalence of postmenopausal bleeding will increase and require evaluation. The etiology of abnormal bleeding requires vigilant assessment, despite the fact that benign or normal findings will be generally encountered. Nagele et al, reported abnormal findings in only 48% of 2500 outpatient diagnostic hysteroscopies performed. However if benign pathology such as polyps and submucosal or intramural fibroids are identified and treated hysteroscopically, high patient satisfaction is achieved.

Organic causes of abnormal uterine bleeding such as pregnancy-related events, genital tract infections, neoplasms, systemic, iatrogenic, and foreign bodies must be excluded. Hysteroscopy or saline infusion sonography (SIS) should never be the first tool utilized in the evaluation of abnormal bleeding. A detailed history and physical examination is still the definite hallmark of the initial evaluation and paves the way for additional studies. A history that is suggestive of premenstrual bloating, premenstrual tension complaints, or classic basal body temperature elevations, are likely consistent with ovulatory cycles. Patients with ovulatory menorrhagia, likely have intracavitary lesions contributing to menstrual disorders. Whereas patients with acne, hirsuitism, obesity, can likely have polycystic ovarian disease, contributing to anovulatory cycles and respond well to medical management.

Office hysteroscopy and SIS have revolutionized the practice of office gynecology and the management of myriad gynecologic conditions. Cost, convenience, accuracy, and patient acceptability of these procedures are clearly preferable to those of traditional dilation and curettage. Although, D&C may be the standard of care, hysteroscopy and SIS are the state-of-the-art for menstrual evaluation. They are not meant to replace a tissue diagnosis, but to alert a gynecologist that intracavitary pathology is present. They direct surgical therapy and treatment. They have become the colposcope of the uterus.

In 1805, a curious endoscopist, Bozzini, used a rudimentary rigid scope to peer into the urethra. This marked the first recorded endoscopic procedure. He was censored for undue curiosity, and his procedure fell into disfavor. Later, in 1850, Pantaleoni reintroduced a 12 mm rigid hysteroscope and is credited with performing the first hysteroscopic procedure. It too, was short-lived, as a result of poor illumination, pain, and complications. Instead, dilation and curettage emerged, and in many gynecologic surveys, remains the gold standard for diagnosis, management and treatment of abnormal uterine bleeding. Despite its low sensitivity, regrettably, D&C often remains the sole tool utilized in the intrauterine evaluation of menstrual dysfunction.

Historical Overview of Endometrial Evaluation

Dilation and Curettage: A Vanishing Procedure

In 1843, Recampier introduced the uterine curette to “scrape off the uterine fungosities” in the belief that removing abnormal tissue would treat menstrual dysfunction. Word later demonstrated the inherent inaccuracies of dilation and curettage.
(D & C). In a study of 50 consecutive patients who underwent D&C, then immediate hysterectomy, 60% of patients had one half of the endometrium curetted, and 16% of patients had less than 25% curetted. Other studies have noted that 4% to 20% of D&C’s yield specimens with inadequate tissue for histologic diagnosis because the separated tissue strands are not evacuated. As many as 10% to 35% of endometrial lesions may be missed by blind D&C. Clearly, a blind D & C should not be the criterion standard for evaluating endometrial pathology.

Office Endometrial Biopsy

The 1970s heralded a new era of endometrial evaluation with the Pipelle (Milex Productions, Chicago, Illinois), Novak, Vabra, (Berkeley Medidevices, Berkeley, CA), and Randall curettes. Office sampling devices have a diagnostic accuracy similar to that of D&C but without anesthesia, at lower cost, and with acceptable patient comfort (20%) report severe cramping; however, blind office biopsy also has limitations and sampling errors similar to those of D&C. They accurately detect cancer but are not sensitive for detecting structural abnormalities, such as polyps or fibroids.

In addition, performing biopsy with the Pipelle currette is limited because the amount of endometrial surface sampled is small (4.5% to 15%), there is a 4% to 10% likelihood of encountering cervical stenosis (which will prevent biopsy), 2% to 6% false negative rate, and the fact that 28% to 70% of biopsies are nondiagnostic.

Fourteen studies using pipelle biopsy, noted the sensitivity to be 90% for cancer detection, and a range of 83% to 90% for hyperplasia.
Pap Test
The pap test is not a screening method for endometrial cancer. It should be included in patients with newly diagnosed abnormal uterine bleeding to exclude cervical and endocervical cancer. Paradoxically, some asymptomatic patients presenting for routine annual examination, may have endometrial cells detected on pap. Zucker, et. al noted a 6% incidence of endometrial cancer, and 13% risk of endometrial hyperplasia. If endometrial cells with atypia are detected, then as many as 25% had endometrial cancer. However, Biscotti (unpublished CCF personal communication), has not found a similar rate of endometrial cancer in asymptomatic patients with benign endometrial cells on pap. The current caveat is: if the patient has unexplained bleeding, and atypical endometrial cells on pap, aggressive work up, including endometrial biopsy. If negative, then saline infusion sonography or hysteroscopy performed.

Office Hysteroscopy
In the 1980s and 1990s, office hysteroscopy became practical because the optics improved with subsequent reduction in hysteroscope diameter. Bradley et al. documented patient acceptability, diagnostic accuracy, cost-effectiveness in 417 patients undergoing office flexible hysteroscopy. The advantages of hysteroscopic visualization include immediate evaluation, direct visualization of the endometrium and endocervix, the ability to detect minute focal endometrial pathology, and the ability to perform directed endometrial biopsies. Hysteroscopy is more accurate in detecting intracavitary lesions, such as polyps and fibroids, than blind biopsy alone. Theoretically, the specificity and positive predictive value of hysteroscopy in cases of abnormal uterine bleeding should be 100%. In practice, however, the false-negative rate is 2% to 4% and is the result of operator error in detecting abnormal endometrial lesions.

The disadvantages of office hysteroscopy include the need for expensive office equipment (camera, insufflator, hysteroscope, video equipment), a skillful and experienced hysteroscopist, and the cost of the procedure. Despite the ease, convenience and patient acceptability of office hysteroscopy, the majority of American gynecologists still schedule patients in the operating room for this procedure. Hysteroscopy is essential in helping to evaluate the patient having an indeterminate or equivocal SIS.

Transvaginal Ultrasound
Transvaginal ultrasound improves visualization of the endometrium and ovaries as compared to transabdominal imaging. Transvaginal ultrasound is better than a blind biopsy for analyzing of the endometrium, but it has disadvantages, too. Unlike hysteroscopy, transvaginal ultrasound permits assessment of myometrial and ovarian morphologic characteristics. Clinically, TVUS is useful if it has a high sensitivity for the detection of endometrial malignancy as well as having a high negative predictive value. The specificity and positive predictive value in detecting endometrial pathology is much lower with TVUS. This is not surprising as the cut-off point for defining a normal endometrium has to be kept low in order that no cancers are missed. Differentiating intracavitary abnormalities (i.e., blood, fibroids, and polyps) is difficult. Fibroids and large polyps can distort measurements of the endometrium. Visualization of the
endometrial echo or endomyometrial complex may also be poor with TVUS. Unlike other radiographic imaging techniques, the quality of the image obtained with transvaginal scanning depends on the expertise, experience, and skill of the operator.

Measuring the thickness of the endometrial echo is important in postmenopausal women because it correlates with potential abnormalities of the endometrium. During the menopause, the endometrium is primarily composed of a thin, basalis layer. Measurement of the endometrial echo represents the apposition of the two basal layers. A normal postmenopausal endometrium is rather monotonous, rarely changes in appearance or thickness. Granberg et al. evaluated 205 patients with postmenopausal bleeding utilizing TVUS and endometrial biopsy. Patients with endometrial atrophy diagnosed by endometrial biopsy had a mean endometrial thickness of 3.4 +/-1.2mm, while those with endometrial cancer, had a mean endometrial thickness of 18.2 mm +/-6.2mm. Using a cutoff of 5 mm, they found a positive predictive value for hyperplasia or neoplasia of 87.3%.

Recently, Smith-Bindman et. al. elucidated clearly the benefits of TVUS in the evaluation of PMB. Symptomatic patients with endometrial echoes > 5 mm demonstrated a sensitivity of 96% for detection of endometrial cancer and 92% for detection of any endometrial disease (cancer, polyps, or atypical hyperplasia). This compares favorably to sensitivities for endometrial biopsies of 85% to 95%. Sensitivity was not influenced by HRT regimen, although the specificity did. Eight percent of women not using HRT had a false-positive ultrasound, compared to 28% of women using HRT.

Briley et. al. evaluated 182 women with PMB by TVUS and compared results to endometrial biopsy, hysteroscopy or hysterectomy specimen. In the 87 patients with an endometrial echo < 5 mm, the negative predictive value was 95%. There were two cases of hyperplasia and one endometrial polyp. But no carcinomas occurred in this group, so, the negative predictive value for carcinoma was 100%. If we assume that a normal post menopausal endometrium is < 5 mm, then 48% of patients in this study could have avoided endometrial biopsy. Thickened endometrium occurred in 82 patients, and there were five carcinomas, nine polyps, and eight cases of endometrial hyperplasia. In five out of the 182 patients in this study the endometrium could not be visualized and in one of these a cancer was present. Sometimes non-visualization is due to atrophy, however the presence of cancer cannot be excluded if the endometrium is not visualized. When the endometrium is not visualized, then SIS is essential.

The usefulness of TVUS in managing bleeding disorders is related to menopausal status. TVUS is an excellent initial diagnostic method for ruling out endometrial abnormalities in postmenopausal patients with bleeding because of the well defined and narrow range of normal endometrial echo. It is of limited use in premenopausal women with irregular bleeding because of the wide range of normal endometrial thickness.

The Nordic trial, published by Karlsson, et.al., involving 1168 women with postmenopausal bleeding is one of the largest to have analyzed the sensitivity and specificity of transvaginal endometrial thickness (from 1 to 72 mm) against histologic findings obtained by D&C. In postmenopausal women with an endometrial echo of less than 4 mm, the sensitivity and specificity for detecting any endometrial pathology was 96% and 68%, respectively. If 5 mm was used as a cut-off, then two endometrial carcinomas would be missed and the probability of missing a pathologic diagnosis was
Bradley Diagnostic Hysteroscopy

6.1%. The endometrial echo was not visualized in 2.8% (n = 30); 30 patients underwent a D&C and 9/30 demonstrated histological findings including; 1 case of endometrial cancer, 1 case of cervical cancer, 1 case of adenomatous hyperplasia with atypia, 5 polyps, 1 case of hematometra. Other findings included; 19 cases of atrophy and 2 cases of “hormonal effects” of the endometrium. In postmenopausal women, TVUS had a sensitivity of 94% in diagnosing an endometrial abnormality and a specificity of 78% using a cutoff of 5 mm for the endometrial echo. It was of limited use in excluding polyps and fibroids. The authors proposed using the 5 mm cutoff so as to avoid missing a diagnosis of endometrial carcinoma.

When a focal lesion is detected by TVUS in a symptomatic patient, it may be more appropriate to perform operative hysteroscopy in order that a focal lesion is removed entirely, rather than relying on the report of a “blind biopsy.”

Saline Infusion Sonography

Introduced in 1981, SIS involves infusing saline into the endometrium during TVUS to enhance the image. Many alternate terms have been used to describe this technique----echohysteroscopy, hydrosonography, sonohysterography, sonohysterosalpingography, sonoendovaginal ultrasound, and saline infusion sonography; we have chosen to use the term saline infusion sonography and in our 1996 paper, coined the acronym SIS (Widrich et al). The acronym SIS is preferable because it can also be used to refer to the more exact definition of the technique, saline infusion sonohysterogram. It is also preferable to the acronym SHG (for sonohysterogram) because SHG can be confused HSG, the acronym used for hysterosalpingogram. Although this latter point may seem superfluous, acronyms are used.

In 1981, Nannini et al. first described the saline infusion technique; they used a rigid catheter and transabdominal scanning and called it “echohysteroscopy.”

Richman et al. first used high molecular weight dextran (Hyskon) for SIS to verify tubal patency when a collection of fluid was demonstrated in the cul de sac. Obviously, this method could only demonstrate that at least one tube was patent and could not determine which tube was open. Performed transabdominally, this procedure had a sensitivity of 100% for bilateral tubal obstruction and a specificity of 96% for tubal patency.

Randolph et al. used intrauterine saline in combination with transabdominal ultrasonography in 1986 and correctly identified uterine abnormalities in 53 of 54 patients who underwent immediate hysterectomy.

A rigid Schultze cannula, was used by Bonilla-Musoles et al. who evaluated 38 patients with abnormal uterine bleeding and found that saline-enhanced endovaginal ultrasonography was more useful than the transabdominal approach.

Using a rigid Reuben’s cannula and vaginal probe Syrop and Sahakian found polyps in 13 of 14 patients with minor, if any, symptoms, evaluated for infertility.

In 1993, Parsons and Lense modified this technique for endovaginal ultrasonography with a 5-Fr insemination catheter. Of 39 patients evaluated for abnormal uterine bleeding 16 had endometrial polyps, 4 had endometrial hyperplasia, 2 had Stage 1a endometrial cancers, and 2 had "endometrial wrinkles." All diagnoses were confirmed by histologic examination of specimens.
Bradley Diagnostic Hysteroscopy

Goldstein reported the benefits of SIS in patients with perimenopausal bleeding. He also recognized the limitations of TVUS alone in evaluating the endometrial echo in patients using Tamoxifen.

In 1996, Widrich and Bradley coined the term SIS in their landmark paper. Comparing hysteroscopy and saline infusion sonography prospectively, they identified additional benefits of SIS compared to hysteroscopy, found a greater sensitivity in detecting endometrial hyperplasia, and few false positive results with SIS, and high patient comfort with SIS.

The transition from conventional TVUS to SIS has occurred rapidly in the last 3 to 5 years as clinical reports and experience have demonstrated that it is superior to transvaginal ultrasound, endometrial biopsy, D&C, and hysteroscopy alone.

Saline Infusion Sonography (SIS)

Technique

Timing

Although SIS can be performed transvaginally or transabominally, in most reports, the transvaginal approach has been used. This procedure can be scheduled at any time during the menstrual cycle, although like hysterosalpinography, evaluation during the early proliferative phase is probably best because the endometrium is at an intermediate thickness at this stage. It is thinnest in the menstrual stage and thickest during the secretory phase. A normal cavity appears smooth during proliferate phase, so abnormalities are more easily seen. Endometrial polyps and uterine fibroids are readily visualized during the proliferative phase. Also, the possibility of interrupting a viable intrauterine pregnancy is unlikely in the proliferative phase. Finally, procedural artifacts are less likely to occur during the proliferative phase.

Performing SIS during the secretory phase increases the risks of disrupting or shearing the copious secretory endometrium and creating “wrinkles” or polypoid projections. Cullinan et al. report that images of fibroids are enhanced during the secretory phase because the echogenic endometrium creates an excellent interface with the hypoechoic fibroid. Endometrial thickness in reproductive-age women should be correlated with ovarian activity. Presence of a corpus luteum should correspond to a secretory endometrium.

About one fourth of women with abnormal bleeding on HRT will have an abnormal TVUS. Fewer false positive results are encountered when TVUS is performed during the estrogen-only phase in women using cyclic HRT. Patients on combined continuous can be evaluated at any time, due to the level hormonal milieu.

Preparation

Except for patients with symptoms or signs of pelvic infection, patients who require antibiotics for procedures, (29) and the optional administration of nonsteroidal anti-inflammatory drugs (NSAIDs) before the procedure, SIS requires minimal preparation and no anesthesia. Voiding before SIS is important. Bladder distention is not required and can shift an anteverted uterus to a retroverted position, making evaluation with the transvaginal probe onerous. After informed consent is obtained, a bimanual examination is performed with the patient in the dorsal lithotomy position. We then perform conventional TVUS using a transvaginal probe. Cervical visualization is aided if
an open-sided speculum is placed in the vagina. Because the speculum is open-sided, it facilitates introduction of the intrauterine catheter and permits the speculum to be easily removed without displacing the catheter.

**The Procedure**

After speculum insertion, the cervix is visualized and cleansed with an antiseptic solution such as Betadine or Hibiclens, and the intrauterine catheter is then inserted. Several flexible intrauterine catheters are currently available that provide easy access to the endometrium. We prefer the 25-cm long, 5.6 French Soules intrauterine insemination catheter (Cook Ob/Gyn, Indianapolis) because it is inexpensive, easy to use, and easy to introduce into the uterus. No published trials have compared the different types of catheters. For conditions such as an incompetent cervix, Asherman’s syndrome, or patulous cervix, a balloon-type catheter is useful to optimize uterine distention and minimize fluid loss.

Before insertion, the catheter is flushed with sterile saline to help decrease bubble artifact. A straight catheter should be introduced with a sterile uterine packing forceps until the fundus is reached. When cervical stenosis is encountered, a tenaculum or uterine sound can be used to assist in placing the catheter. After the catheter is placed, the open-sided catheter can be removed. If a Soules catheter is used, it will protrude from the vagina, allowing a 60-mL plastic syringe containing sterile saline to be easily attached. Any sterile clear liquid can be used to perform SIS, as long as it is safe for solution to enter the peritoneal cavity if the tubes are patent. Gaucherand et al. described instillation with lactated Ringers solution, glycine, as well as with normal saline. Saline infusion sonography is a dynamic procedure and images are best seen in real time. Usually excellent images and adequate distention are obtained with minimal fluid volume, from 5 mL to 30 mL. We infuse the saline at a rate of about 5 mL-10mL/min; if the uterus cannot be distended, placing balloon-tipped catheter and infusing the saline more slowly may help. Air bubbles may accumulate, but they rapidly disappear as the injection continues.

A systematic technique for viewing the uterus is essential. The uterus is a three-dimensional structure that has to be skillfully recreated during scanning. By scanning from cornua to cornua in the long axis (sagittal plane), then turning the probe 90° and scanning from the endocervix to the fundus, a three-dimensional image will be recreated. The sagittal view allows visualization of the uterine cavity and measurement of the endometrial echo. The adnexa is visualized in the semicoronal plane. The cervix and cul de sac are viewed as the transducer is withdrawn. Uterine symmetry and myometrial or intracavitary lesions are best appreciated by slowly scanning transversely from the external os to the fundus. Fleisher et al. recommends measuring both layers of the endometrial echo (which represent the anterior and posterior uterine wall basal layers) in the sagittal view to obtain the most accurate measurement of the endometrium. The hypoechoic subendometrial halo should not be included because it represents the vascular layer of myometrium. Both procedures can be performed in 10 to 15 minutes.

**Post-procedure instructions**

Saline infusion sonography is associated with few complications. Patients are instructed to contact the office in the event of increased temperature, foul-smelling discharge, or persistent pelvic pain. Immediate return to work after SIS is customary.
Procedural difficulties
Few risks are associated with SIS. A bimanual examination and direct visualization of cervical and vaginal discharge are imperative before the procedure. Manipulation of the uterine cervix can produce a vasovagal reaction. Rarely patients may also experience bradycardia, dizziness, or severe pain. Resuscitative equipment should be readily available.

There have been no published reports of uterine perforation with SIS. The procedure causes only minimal pain. One to 2 hours before the procedure, nonsteroidal anti-inflammatory drugs can be administered although pain scores do not seem to drop appreciably.

The likelihood of transmitting metastatic endometrial cancer through the fallopian tubes during SIS is purely speculative. The small amount of fluid used, coupled with the low intrauterine pressures, minimizes the risk to the patient. Also, historically, staging of endometrial cancer was routinely performed with HSG. DeVore et al. found no evidence of worse-than-normal outcomes when comparing prognosis, dissemination of disease, or peritoneal metastasis in patients with endometrial cancer evaluated with HSG.

Findings
Saline infusion sonography allows the clinician to evaluate the uterus for intracavitary lesions. Additionally, it the causes of increased endometrial thickness can be differentiated. Although classic or representative features of uterine polyps and fibroids are readily discerned with SIS, endometrial texture and thickness appear similar in the two conditions when evaluated with SIS.

The Normal Scan
The endometrium is dynamic, responding rapidly to ovarian stimulation and endogenous and exogenous hormonal stimulation. This responsiveness is reflected in the endometrial appearance, echogenicity, and thickness. Under SIS, a normal endometrium appears symmetrical, well demarcated, and surrounds the anechoic saline. In the premenopausal patient, endometrial thickness varies between 4 and 8 mm during the proliferative phase. The secretory phase ranges from 8 and 14 mm. Ovarian appearance (i.e. corpus luteum), and the presence or absence of secretory endometrium is instructive. An endometrial thickness of less than 5 mm in postmenopausal women not receiving hormonal replacement therapy is associated with a low incidence of endometrial cancer, being more often associated with benign pathologic findings (polyps and fibroids) than adenocarcinoma of the endometrium. The endometrium surrounding polyps and fibroids is most often within normal limits.

The Abnormal Scan
Endometrial Polyps
Endometrial polyps widen the endometrial echo and create the appearance of increased endometrial thickness with conventional TVUS. Kupfer and associates using TVUS noted that benign polyps were smaller when compared with variegated and heterogeneous (complex) polyps. Likewise, complex polyps are often associated with more complex histologic findings, including infarction, hemorrhage, and cystic changes,
Bradley

Diagnostic Hysteroscopy

as well as microscopic carcinoma. Benign endometrial polyps appear well defined and
are uniformly homogeneous or hyperechoic with SIS. Although polyps may distort
measurements of endometrial thickness before saline infusion, the endometrium can be
measured separately from the polyp.

Hulka retrospectively reviewed 68 postmenopausal women evaluated by TVUS
and noted that a cystic space within an abnormally thickened endometrium was more
predictive of polyps. The cystic spaces detected with sonography were associated with
dilated glands found at histologic examination. In contrast to TVUS alone, SIS can
differentiate pedunculated from sessile polypoid masses. During fluid instillation,
polyps undulate as the anechoic fluid surrounds them; their attachment, stalk size, and
location are easily seen with SIS. Polyps typically do not distort the endomyometrial
complex.

Intrauterine Fibroids

With conventional TVUS, fibroids are difficult to locate because they transmit
sound poorly, attenuate the sound beam, and have ill-defined borders. Fibroids may
obscure endometrial measurements when only TVUS is used because they create an
irregular interface between the endometrium and myometrium. In addition, fibroids may
vary in appearance, having calcified, hypoechoic, echogenic or isoechoic, and mixed
echogenic patterns. Degenerating fibroids often appear cystic.

Saline infusion sonography is distinctly advantageous to conventional TVUS and
hysteroscopy: SIS allows fibroids to be easily and accurately classified by location, size,
and degree of intramural extension. Further, they can be evaluated for hysteroscopic
resectability, a major advantage as the ability to completely resect intracavitary fibroids
affects clinical outcome and surgical complications. Hysteroscopy does not determine the
depth of myometrial involvement of fibroids. Only pedunculated submucosal fibroids
can be fully assessed with hysteroscopy. Beware of the “tip of the iceberg phenomenon,
whereby, the hysteroscopist may only visualize the submucosal component of a fibroid.
Full resection may not be possible if a transmural fibroid is encountered.

Wamsteker et al. found that the likelihood of complete resection depended more
on the depth of intramural involvement of the fibroids than on their size, number, or
location. Concomitantly, with more extensive intramural involvement, the mean number
of hysteroscopic procedures necessary to achieve complete resection increased. The risks
of intravasation of fluid and surgical complications increased were even greater for
transmural fibroids, and surgical time increased.

Using transabdominal sonohysterography, TVUS with saline infusion, and
hysteroscopy, Cicinelli and colleagues evaluated 52 premenopausal women who were
scheduled for hysterectomy to treat uterine fibroids. Each procedure was successfully
completed in each patient. Hysteroscopy less accurately predicted fibroid size than did
SIS. The size estimates were significantly less accurate with hysteroscopy than with the
other two sonographic techniques----in some cases, the recorded sizes differed by more
than 12 mm. The SIS evaluation of submucosal fibroids was more precise than that of
other techniques, differing from direct measurement by no more than 5% to 10% when
compared to pathological results from hysterectomy.
**Endometrial Hyperplasia**
Endometrial hyperplasia cannot be diagnosed with SIS alone because the ranges of endometrial thickness in hyperplasia and carcinoma overlap. A histologic diagnosis based on a hysteroscopically obtained or an endometrial office biopsy specimen is also required. Most hyperplasias of the endometrium are 0.6 to 1.3 cm thick in postmenopausal patients, with a mean thickness of 1 cm. In most endometrial cancer, the thickness is more than 4.7 mm. Most often, hyperplasia occurs diffusely; however it can be focal or appear as a broad-based polyp. Hulka et al. retrospectively studied 68 postmenopausal women with TVUS and found that in endometrial hyperplasia, the endometrium often appeared hyperechoic. Saline infusion sonography may also reveal asymmetrical or multifocal areas of endometrial irregularities in endometrial hyperplasia. The endometrial-myometrial interface is intact.

**Endometrial Cancer**
Endometrial cancer is difficult to distinguish from hyperplasia except when the endometrium is irregular, has mixed echogenicity, has irregular borders, demonstrated endomyometrial interface disruption, or demonstrates “bridging of the endometrium”. Most studies report that the endometrium is thicker in patients subsequently found to have malignant endometrial pathology than in patients with benign conditions, although the range of thickness may overlap between the two conditions, as mentioned above. The postmenopausal patient not receiving hormonal replacement therapy usually has an endometrial echo less than 4 mm thick. An endometrial echo of less than 5 mm is rarely associated with endometrial cancer. However, as the endometrial echo thickens, the positive predictive value of the test increases.

**Endometrial Atrophy**
Atrophic endometrium is composed of sclerotic blood vessels and glands. The glands may dilate and appear as cystic spaces during TVUS. Atrophic endometrium in postmenopausal patients appears as an endometrial echo less than 5 mm thick.

**Intrauterine Adhesions**
Adhesions appear as thin or thick bridging bands that may distort the endometrium. The endometrium may be difficult to distend during saline infusion. During real time scanning, one can easily see adhesion movement.

**Tamoxifen-Induced Changes**
Endometrial surveillance of asymptomatic patients taking Tamoxifen does not differ from that of women routinely using estrogen replacement therapy. Although most long-term users of Tamoxifen will have an inactive endometrium, some will show increased endometrial thickness during conventional TVUS.
Goldstein and others recently advocated SIS to monitor the source of increased endometrial thickness because highly unusual, heterogeneous, and centrally located uterine changes have been noted during conventional TVUS. If SIS is not performed,
then these unusual features noted with TVUS can easily be overinterpreted. Unlike TVUS, SIS can reveal the true location of the abnormalities and thus indicate whether additional investigation is necessary. SIS can identify the subendometrial sonolucencies to the proximal myometrium. The abnormalities may represent “abnormal adenomyomatous-like changes in the proximal myometrium” that are microcysts. When viewed microscopically, the junction between the endometrium and myometrium is irregular and nonlinear, whereas in patients not receiving Tamoxifen, the junction is linear.

Other ultrasonographic TVUS findings observed in patients taking Tamoxifen as compared to control patients consist of increased uterine volume and depth, greater endometrial thickness, increased incidence of endometrial polyps (36% vs 10%), and increased endometrial atrophy (28% vs 87%). A slight increase in the incidence of endometrial cancer of 2 to 3 cases per 1000 women has been noted among Tamoxifen users.

The Clinical Role of SIS in Evaluating Menstrual Disorders

Current Indications

The indications for SIS are:

- abnormal uterine bleeding in pre or post menopausal patients
- evaluation of an endometrium that is thickened, irregular, unmeasurable, or poorly visualized on conventional TVUS, computed tomography, or magnetic resonance imaging studies
- irregular bleeding in women receiving exogenous hormone therapy
- a central endometrium that is thickened or bizarre appearing in women receiving Tamoxifen
- the need to differentiate between sessile and pedunculated masses of the endometrium
- evaluation of recurrent pregnancy loss or IVF candidates when knowledge of tubal patency is not essential to patient management.
- pre surgical evaluation of intracavitary fibroids

Evaluation of menstrual dysfunction in premenopausal women

The greatest benefit of SIS in the reproductive-age patient with menstrual dysfunction is a precise localization of intrauterine lesions. In the series of Widrich et al. which consisted mostly of premenopausal women with abnormal uterine bleeding a sensitivity of 96% and a specificity of 88% were reported. Discordance between SIS and hysteroscopy was mainly in overdiagnosing polyps or misdiagnosing a polyp for a fibroid or vice versa. There were no false negatives.
Preoperative evaluation for endometrial ablation

Because of patient preference, the number of endometrial ablations is increasing, so the need for thorough preoperative evaluation is even more essential. Preoperative evaluation with SIS permits rapid and accurate detection of uterine pathologies such as intramural or transmural fibroids, larger endometriomas, and hydrosalpinx. The deep location of fibroids prevents treatment with the rollerball or resection techniques. In such cases, patients can be offered the option of a myomectomy or uterine artery embolization, as an alternative to hysterectomy. If submucosal fibroids are detected, then hysteroscopic removal is advocated.

Special thoughts about the post-menopausal patient

Hormone replacement therapy (HRT) may be associated with increased incidence of spotting, irregular bleeding, or staining, during the initiation of therapy. In general reassurance is all that is needed, since 20%-25% of patients with abnormal bleeding within the first six months resolve. However, the American College of Obstetricians and Gynecologists (ACOG) recommend evaluation of patients who have persistent heavy prolonged or erratic bleeding. Thus, many women will need diagnostic evaluation if bleeding on HRT persists. The most common cause of bleeding in the menopause is the result of endometrial atrophy, even among women receiving HRT. Remember that the baseline prevalence of endometrial polyps is 20%, and for some women, the use of HRT may produce bleeding in women previously with asymptomatic polyps. Additionally, submucosal fibroids may also cause bleeding.

Patients on cyclic combined estrogen/progesterone therapy should receive a minimum of 12-14 days of progestin therapy. Patients who bleed before day 11 of a cyclic progestin regimen should undergo endometrial biopsy. If secretory or pseudo-decidual changes are not evident, then additional progestin should be used. Patients using cyclical estrogen/progesterin therapy experiencing bleeding should be reassured if their bleeding occurs during the final 12-14 days of progestin regimen or the week following progestin withdrawal.

The office evaluation of abnormal post-menopausal bleeding should be comprehensive in patients who continue to bleed for greater than 3-4 months or, if the bleeding is annoying, and the patient can not be reassured. We cannot expect all patients to tolerate the common advice of “just wait it out.” Many women will not, and cannot tolerate such an approach. Thereby, losing the benefits of hormonal therapy.

Currently, endometrial pipelle biopsy is commonly used in the office evaluation. Endometrial pipelle biopsy has a low sensitivity for detecting endometrial polyps and fibroids, compared to saline infusion sonography (SIS) or office flexible hysteroscopy. Patients with symptomatic postmenopausal bleeding on hormone replacement therapy who have had negative “blind” evaluation with endometrial pipelle biopsy should have further evaluation with SIS or office hysteroscopy.
Clinical Considerations

All women with postmenopausal bleeding require thorough work-up to exclude endometrial cancer or endometrial hyperplasia with atypia. While endometrial pipelle biopsy has been demonstrated to be cost-effective, newer technology may further define and determine the likely causes of bleeding, when the endometrial biopsy is insufficient or indeterminate.

When the endometrial biopsy is insufficient, indeterminate, or cannot be performed, then there are two additional ways to evaluate the patient with an underlying risk of neoplasia. Recently, and gaining momentum is transvaginal ultrasound. It has been helpful in identifying patients with an increased risk for neoplasia or its precursors, endometrial hyperplasia. The endometrial measurement (endometrial echo/endometrial stripe) is helpful in categorizing patients into a low-risk versus a high-risk group. The exact cutoff measurement chosen is a function of the sensitivity and specificity sought. Most clinicians use a cutoff of 5 mm to define a low-risk patient group, whose combined risk for cancer and atypical hyperplasia ranges from 2% to 3%. Stratification of patient risks into low-risk groups include: patients age less than 70 years old, multiparous, bleeding that occurs within one year of menopause, and a nondiabetic patient. In contrast, patients with an endometrial echo of greater than 5 mm, have an increased risk of endometrial cancer and atypical hyperplasia approaching 5% or more. Patients with all four risk factors; diabetes, nulliparity, age > 70 years, and bleeding that occurs more than one year after menopause, have an 80% risk for endometrial cancer or complex hyperplasia. Unfortunately, many articles evaluating the usefulness of the endometrial measurement, have included asymptomatic patients, and therefore, it is likely that patients presenting with bleeding may have a higher detection rate, than asymptomatic patients.

In a study of 265 patients with postmenopausal or perimenopausal bleeding with a nondiagnostic endometrial biopsy, 2% were found within a 2-year period to have cancer and 3% demonstrated atypical hyperplasia. Therefore, it is imperative that patients with persistent, unexplained bleeding, triaged with conventional endometrial pipelle biopsy, need aggressive evaluation.

Endometrial polyps and fibroids are common causes of PMB. Patients evaluated with TVUS measurements of the endometrium, may have altered endometrial echoes due to the intracavitary mass. In addition false negative sampling errors occur in such patients.

To diagnose endometrial cancer, which occurs in 10% of women with postmenopausal bleeding, diagnostic testing is essential. However, its detection rate increases with age, especially in women greater than 60 years. It can present as a variegated, multifocal lesion, or isolated lesion within a polyp. Endometrial cancer can be missed by blind sampling. In a review of 2007 hysteroscopic procedures, endometrial cancer was missed in 10 of 30 patients when cancer was suspected by hysteroscopy, when the sampling technique to remove the suspected lesion was non-directed. The endometrial biopsy have similar accuracy in the diagnosis of endometrial cancer.
Several studies have shown that endometrial thickness, as measured by TVUS, is related to endometrial pathology in postmenopausal women. A recent report by O’Connell et al. in 100 postmenopausal patients with abnormal bleeding revealed a sensitivity of 95% and a specificity of 98% if endometrial biopsy and SIS were used for the investigation. Discordance of SIS with hysteroscopy and D&C occurred as a result of overdiagnosis (2 cases) polyps, underdiagnosis polyps (2 cases) and in patients taking Tamoxifen. Although no cancer or hyperplasia was detected in patients with an endometrial thickness of less than 4.7 mm, other pathology such as polyps (6 cases) and fibroids (2 cases) were detected.

In patients with postmenopausal bleeding, evaluated by TVUS, 52% will have an abnormally thick endometrium and 3% will have an inconclusive ultrasound findings or an unmeasurable endometrial echo. Further evaluation would be necessary in 55%. We would therefore recommend SIS for initial triage of all patients with postmenopausal bleeding. Infusion of saline at the time of TVUS would not add much time to the procedure. If there is a symmetrical thickening of the endometrium we would also perform a biopsy. If there is an atrophic endometrium surrounding an intracavitary polyp or fibroid, we would recommend hysteroscopic removal. If there is a focal thickening of the endometrium, we would recommend hysteroscopic directed biopsy. Finally, in patients with a negative SIS and biopsy persistent bleeding, we would recommend an office hysteroscopy, to detect the rare lesion likely near the cornua or lower uterine segment, or small lesion that escaped view by SIS.

Potential Limitations of Saline Infusion Sonography

Although SIS has many benefits, Widrich et al., were unable to complete examinations in patients with a uterus greater than 12 to 14 weeks in gestational size, submucosal fibroids larger than 4 cm, or large transmural fibroids. For patients with cervical stenosis, one should consider mechanical dilation. Some authors have found it difficult to catheterize patients with a markedly retroverted uterus, isthmic synechia, cervical stenosis, or an intrauterine septum. Cervical traction with a single-tooth tenaculum straightens the uterine axis in cases of marked retroversion. Additional limitations include the potential inability to thread the catheter, kinking of the catheter, endometrial pseudopolyps, the introduction of air bubbles into the uterus, and the inability to distend the uterine cavity in cases of patulous cervix. Imaging may be difficult in the uterus that is markedly retroverted, retroflexed, or markedly anteverted.

In premenopausal women, the endometrium varies in thickness because of the menstrual cycle. Observing patients through several menstrual cycles and verifying the presence of cyclical ovarian activity and endometrial sloughing may obviate the need for endometrial biopsy.

Indications for Office Hysteroscopy

Hysteroscopy is an integral component in the office evaluation of abnormal uterine bleeding. It should be utilized in any clinical situation where direct inspection of the uterine cavity will improve diagnostic accuracy, increase the sensitivity in detecting
endometrial disease, or enhance patient therapy. The following clinical situations account for the majority of the indications for office hysteroscopy. It is obvious, that many of the indications for hysteroscopy overlap those for saline infusion:

- Unexplained uterine bleeding in either premenopausal ovulatory women, premenopausal anovulatory women who fail medical therapy, and postmenopausal bleeding
- Infertility evaluation: routine triage, pre-IVF evaluation, follow-up evaluation for an abnormal hysterosalpinogram or indeterminate saline infusion sonography (SIS), or evaluation of recurrent miscarriage
- Persistent post partum or post abortion bleeding
- Localization of foreign bodies such as misplaced intrauterine device (IUD) when the string is not visible. Hysteroscopy helps to determine if the myometrium is perforated.
- Evaluation of the pregnant patient including evaluation of the endometrial cavity after postpartum hemorrhage, difficult D&C, IUD in pregnancy, and evaluation of retained products of conception
- Increasingly, transvaginal ultrasound (TVUS) is being used in the evaluation of abnormal bleeding. However in 3% of cases the endometrial echo may be obscured, indeterminate, or cannot be evaluated. In these situations, hysteroscopy permits rapid endometrial surveillance.
- Hysteroscopy is mandated for patients with abnormal bleeding in the face of "blind" evaluation with dilation and curettage or negative endometrial biopsy results, or normal SIS findings
- Abnormal pap tests in postmenopausal women with atypical endometrial cells on pap or atypical glandular cells on pap (to exclude an endometrial cancer or hyperplastic)
- Preoperative endometrial evaluation of women undergoing abdominal myomectomy, endometrial ablation, or adhesiolysis
- Preoperative office hysteroscopy is useful in evaluating the extent of disease in women with suspected endometrial hyperplasia, fibroids, or polyps.
- Post operative evaluation of myomectomy (abdominal and hysteroscopic) site, evaluation of cesarean section scars, adhesiolysis, and endometrial ablation failures
- Evaluation of congenital uterine malformations including unicollate uterus, uterus didelphys, and septate or bicornuate uterus.

**Hysteroscopic Illusions**

The hysteroscopist must remember that the sizes of lesions noted with hysteroscopy are not as accurate as with transvaginal ultrasound. The eyepiece is focused at infinity, thereby making the objects that are closer appear magnified, and objects viewed further away smaller. This phenomenon can lead to surprises in the operating room, especially when the size of a lesion is underestimated.
Distention Medium

CO2 is inexpensive, readily available, easy to use, well tolerated and provides excellent intracavitary visualization. Bubbles can impede the view when active bleeding is present, but nevertheless, CO2 can be tried, if bubbles occur, switching to liquid based medium usually works. One clinical caveat worth remembering when using CO2: observe the intrauterine architecture while decreasing the intrauterine pressure to the lowest amount, so that the "disappearing phenomenon" can be detected. A negative hysteroscopic view may be encountered when the intrauterine pressure rises and literally "pushes" an intracavitary lesion such as fibroids into the myometrium, or flattening polyps and hyperplastic lesions against the endometrium. Over distention may create a "negative" hysteroscopic appearance or the illusion of a normal hysteroscopic examination. While office hysteroscopy is quick, gynecologists should get in the habit of slowly deflating the uterine cavity, patiently wait and re-inspect the endometrial surfaces slowly and carefully. Remember to document this technique in your office dictation. This clinical pearl, if followed consistently, will produce more accurate findings, less false negative findings and ultimately better outcomes.

When copious bleeding occurs, an aqueous medium works best for visualization. This can be administered with 60 ml syringes or a separate inflow liquid system. If large quantities of blood are encountered, try irrigating with 100-300 cc of fluid, aspirating the fluid through a syringe, and then redistend with fluid. Flushing the endometrium of debris and clots will usually lead to an improved view. If you cannot see despite these attempts, reschedule the patient another day in the office or reschedule the case in the operating room where higher-pressure infusion pumps can be used. Never make a diagnosis when you cannot adequately visualize the endometrium adequately. Remember there are circumstances that prohibit an office evaluation.

What's Capable of Being Visualized

Proper patient scheduling is essential in premenopausal women. The endometrium changes continually throughout the menstrual cycle. The cyclical endometrial changes are objectively documented with transvaginal ultrasound. Menstrual endometrium is thin, proliferative endometrium ranges from 4-8 mm, and secretory endometrium ranges from 7-14 mm. The best hysteroscopic view in women with normal menstrual cycles is the early proliferative stage. Hysteroscopy performed between days 4-11, provides a clear unparalleled view the early proliferative endometrium. Later, visualization may be hampered by lush, thick secretory endometrium, which causes more false positive reports of polyps or hyperplasia.

Lesions that may be visualized hysteroscopically include: endometrial polyps, submucosal and intramural fibroids, synchiae, retained products of conception, foreign bodies, endocervical lesions, endometrial atrophy, endometrial hyperplasia, endometrial cancer, arteriovenous malformations, gestational trophoblastic disease, and pregnancy. Infrequently, endometrial gland openings (Asherman's) may be visualized.
Emergency Protocol

Your office should have an established emergency protocol for all patients scheduled for invasive procedures, SIS and hysteroscopy. In general, less than 1% of patients will experience a vasovagal reaction. However, you must be prepared to respond to this complication. Your office staff should know the protocol, location of an emergency cart, and insure that emergency equipment is readily available and working. Test your emergency cart periodically with a mock drill so that your office staff is prepared in the event of an emergency.

Fortunately, most patients with a vasovagal reaction recover simply by stopping the procedure. Others may require steep trendelenburg position, smelling salts (spirits of ammonia), or a cool clothe. Rarely, atropine is required for resuscitation.

Conclusions

One of the most significant advances in the evaluation of postmenopausal bleeding has been the progression from “blind techniques” such as D&C and endometrial biopsy, to the emergence of transvaginal ultrasound evaluation, augmented by SIS for enhanced views. Clearly there is a growing acceptance of TVUS in the algorithm of PMB, as an alternative or replacement of endometrial biopsy alone. When the endometrial echo is 5 mm or less, the frequency of significant endometrial abnormality is 0.1% (in HRT users) and 1% (in nonusers).

When the endometrium can not be clearly seen, lacks homogeneity, and is not uniformly 5 mm or less, then SIS is extremely helpful. Focal and global endometrial pathology can be differentiated with SIS. Saline infusion improves the sensitivity for the detection of endometrial abnormalities. Saline infusion sonography (SIS) overcomes the limitations of traditional TVUS and has substantially improved uterine cavity assessment for menstrual disorders. Saline injected through the cervix creates an acoustic window, allowing three-dimensional investigation of the uterine cavity and ovaries, as well as enhancing images of the endometrium and myometrium. The technique is superior to TVUS alone. Saline infusion sonography also has a number of advantages over other techniques for evaluating menstrual disorders: distention of the uterine walls creates a three-dimensional view of the uterus, an enhanced view of the endometrial echotexture, and clearer images of structural abnormalities involving the endometrium and myometrium. This information is helpful because it determines whether an endometrial biopsy is needed, the type of surgical procedure that may be needed, the level of hysteroscopic expertise required to remove lesions, and the lesion resectability. In addition, it is more acceptable to patients, less expensive than hysteroscopy, and can be performed quickly in the office.

The continuing challenge for gynecologists is to provide patients with cost-effective, minimally invasive evaluation, and directed therapy for menstrual dysfunction. Physicians and nurse practitioners who do not perform office endometrial biopsy, may find that obtaining a TVUS will help triage and direct patient care. Those with abnormal results would then benefit from SIS or hysteroscopy, with or without endometrial biopsy depending on results. Saline infusion sonography targets' patients needing biopsy, directs the surgical approach, and minimizes office diagnostic hysteroscopy --- all with a quick
Bradley Diagnostic Hysteroscopy

office procedure. For patients, the benefits include minimal and brief discomfort and a better understanding of intrauterine pathology through viewing the ultrasound monitor. Women also appreciate the ease of scheduling, the minimum time away from work, and that no escort is needed after the procedure. Unnecessary scheduling of diagnostic D&C’s in the operating room can be avoided.
Algorithm for the evaluation of postmenopausal uterine bleeding

TVUS + SIS

Abnormal endometrium or intracavitary lesion

Focal thickening
Symmetrical endometrium
Polyp or fibroid

Directed biopsy
Office biopsy
Hysteroscopic removal

If persistent bleeding
Office hysteroscopy

Bradley

Diagnostic Hysteroscopy

References


6 Apgar B, Dewitt D: Diagnostic Hysteroscopy. American Family Physician 46, 5: 19S-26S.
PART II

PROCEDURES
Laparoscopic Sterilization Procedures

Richard Soderstrom MD
Clinical Professor
Department of Obstetrics & Gynecology
University of Washington
Laparoscopic Sterilization Techniques

—Basic Requirements—

Preamble

Because female sterilization is one of the most common surgical procedures performed by gynecologists, litigation following sterilization failures has a significant impact. When the standard of care is questioned, it is usually a departure of “standard of technique.” The best way to correct this problem is through proper didactic education and observation during one’s residency education. The following is a brief, concise overview of information that should be the core basis for such education.

History and Experience

For the past three decades, the laparoscopic methods of female sterilization have received wide attention in the literature focusing on electrical or mechanical methods. Each method was designed and developed by inventors who made clear recommendations as to the proper use and application of their technique and method. Of these, the bipolar electrical methods has been the most popular.

Unfortunately, different techniques may be “modified” by an individual surgeon, who in essence invents another method without the luxury of adequate statistics. Until recently, statistical reports on the success and/or failure of techniques were usually flawed because of anecdotal experience, retrospective review and short-term follow up or subject to “lost to follow up” bias. In April 1996, the Center for Disease Control (CDC) published the only prospective study of the common methods of sterilization used in the United States.\(^1\) It took fourteen years and over 10,000 patients to obtain a ten year follow up of each technique studied. More than a dozen teaching centers participated making the power of the outcome statistics strong. The following comments are summarized from this report.

Of the laparoscopic procedures described, unipolar electrocoagulation without transection has the lowest failure rate of all of the laparoscopic techniques to date. In recent years, problems with a high bipolar failure have become apparent including late ectopic pregnancies. Incompatible equipment and inadequate coagulation appear to play a major role in these failures.\(^2\) In general, when ring failures occur, it is secondary to spontaneous reanastomosis. Frequently, failures associated with a clip follow placement of the clip too distal on the tube, at oblique angles to the axis of the tube or misapplied to other structures.
Basic Requirements

When performing laparoscopic female sterilization, the following outlines the basic requirements as described by those who invented or developed each sterilization method.

Electrical Methods—Unipolar or Bipolar

- Always use the cutting mode set at 25 to 30 watts. Most bipolar generators only deliver electrical current in the cutting/desiccation mode or waveform.

- Desiccate at least 2.0 cm, preferably 3.0 cm of contiguous tissue. There is no data support desiccation followed by transection as any improvement.

- Desiccate the isthmus portion of the fallopian tube; spare the cornua to reduce fistula formation.

- With bipolar instruments, the use an ammeter until current flow reaches zero reassures the surgeon that complete desiccation has occurred.

Clip Methods

Place a clip 3 cm from the cornua at a 90 degree angle. With the Hulka Clip™, check for the “envelope” sign (a flattening of the grasp area of the tube) after application. If in doubt, apply another clip adjacent to the first.

With the Filshie Clip™, expose the lower jaw seen through the mesosalpinx before closing the clip on the tube.

Band Method

Because the silastic rubber band may lose its memory if it is stretched over the applicator beyond 15 minutes, apply the silastic band to the band applicator just before application. Grasp the isthmus portion, 3-4 cm from the cornua. Squeeze the applicator handle slowly to reduce the risk of tubal transection.


Laparoscopic Management of Ectopic Gestation

Richard P. Buyalos, M.D.
Associate Clinical Professor
Department of Obstetrics & Gynecology
University of California, Los Angeles

Malcolm G. Munro M.D.
Professor
Department of Obstetrics & Gynecology
University of California, Los Angeles
INTRODUCTION
Ectopic gestations now account for approximately 1.3% of all clinically recognized pregnancies in the United States and Canada. This represents a fourfold rise over the last 20 years. Fortunately, advances in diagnosis and treatment have reduced both the morbidity and mortality associated with this condition. The widespread availability of ultrasonography and accurate and sensitive hCG assays have dramatically facilitated the early detection of ectopic pregnancy. Contingent upon the patient’s desire for future fertility and the nature of the ectopic gestation, both conservative and more extensive surgery may be performed laparoscopically. Perhaps, no other surgical condition has been impacted as greatly by laparoscopic treatment as has tubal gestation, previously treated exclusively by laparotomy.

DIAGNOSIS OF ECTOPIC GESTATION
The early diagnosis of ectopic pregnancy allows for laparoscopic treatment of tubal pregnancy prior to significant adnexal damage and/or hemorrhage. Very early diagnosis also offers the option of medical therapy with the antimetabolic agent methotrexate, an approach that, in appropriately selected patients, usually obviates the need for surgical intervention. While a detailed review of the diagnosis of ectopic gestation is beyond the purview of this syllabus, it is clear that all women of reproductive age who present with pelvic pain and abnormal uterine bleeding should be considered for hCG screening and ultrasonic evaluation of the pelvis when clinically indicated. Increased surveillance for this condition is particularly important for patients with significant risk factors including a prior history of tubal surgery, ectopic pregnancy, and/or pelvic inflammatory disease.

GENERAL CONSIDERATIONS
Prior to taking the patient to the operating room for laparoscopic treatment of ectopic pregnancy the surgeon must have sufficient skills in operative laparoscopy, appropriate instrumentation, and suitable support personnel. Published reports as early as 1988 by Reich et al confirmed that there are few absolute contraindications to laparoscopic treatment of ectopic pregnancy. In their report of 109 consecutive ectopic pregnancies, 16 were ruptured, 3 had unstable vital signs, and 3 were interstitial. None of these patients required laparotomy for treatment and there were no intraoperative complications.

INSTRUMENTATION and OPERATING ROOM ORGANIZATION
Operating room personnel must be familiar with principles of patient positioning, anesthesia and instrumentation necessary for successful laparoscopic surgery for ectopic gestation. While a variety of specific operative laparoscopic instruments can be used for the treatment of ectopic pregnancy, the operating room should be equipped with the following essential items.

1. Laparoscope of suitable diameter with light source
2. Video imaging system
3. High-flow insufflator
4. Electrosurgical generator
5. Ancillary trocar-cannula systems 3-5mm and 11mm diameter
6. Aspirator/irrigator device, preferably with the option of a large diameter (10 mm) for removal of clots.
7. Unipolar needle or blade-shaped laparoscopic electrodes
8. Bipolar electrosurgical forceps
9. Appropriate grasping/manipulating forceps
10. A device or method for removing the products of conception and/or adnexal structures
Buyalos & Munro  Laparoscopic Management of Ectopic Gestation

11. 22 gauge spinal needle with which to inject dilute vasopressin solution

The anesthesiologist should administer endotracheal general anesthesia with sufficient muscle relaxation for laparoscopic surgery. The patient should be positioned in low lithotomy position, the bladder drained, and a device for uterine manipulation placed provided there is certainty that there is no potentially viable intrauterine gestation. A “diagnostic” laparoscope will maximize illumination but an operative laparoscope with an instrument port can be used. Video monitoring is useful to maximize assistant involvement. In addition to the cannula for the laparoscope, at least, two ancillary lower abdominal ports are required.

SALPINGECTOMY VS SALPINGOTOMY

Women desiring future fertility and in whom the fallopian tube is not severely damaged are generally treated with linear salpingostomy or salpingotomy. Salpingostomy refers specifically to tubal reconstructive surgery of distal (fimbriated end) tubal obstruction where the surgeon tries to create a functioning stoma. Salpingotomy refers to incisions made elsewhere in the fallopian tube, usually for the removal of an ectopic gestation. If the salpingotomy is not closed with suture is is left to heal by secondary intention.

Salpingotomy

After the evacuation of blood and clots, the tube and ovary should be mobilized. I have found the administration of 2-4 cc of dilute vasopressin in saline (0.4U/cc or 1 20 Unit ampoule of vasopressin in 50cc N/S) in the mesentery of the fallopian tube prior to the incision to be helpful in maintaining hemostasis. The solution can be administered via a 22g spinal needle delivered directly through the abdominal wall into the mesentery which has been stabilized and elevated with forcep(s) inserted via one of the suprapubic ports. Such needles are more readily available and are generally sharper and easier to use than the larger diameter needles designed for use through laparoscopic cannulas. Delayed bleeding has not been a problem.

The tube should be manipulated carefully to optimize future reproductive potential. In most instances direct grasping can be avoided by pressing the mesentery of the involved tube against the ipsilateral pelvic sidewall, or the pelvic brim with a blunt probe. The probe is then gently manipulated to appropriately orient the antemesenteric side of the ectopic with the laser, scissors or electrode. Then, a linear, antemesenteric incision of appropriate size (usually 1-2cm) is accomplished with a unipolar needle electrode, electrosurgical scissors, or laser contingent upon the surgeon’s preference. Generally, the incision should be made in the proximal aspect of the most distended portion of the fallopian tube. This is because blood clot tends to actually distend the tube distal to of the ectopic gestation following the path of least resistance. Bleeding from the incision site is invariably minimal provided the pre-incisional use of dilute vasopressin solution. Attempts to manually remove the products should be delayed for, with time, the gestation will usually spontaneously extrude through the incision. Gently bending the tube with two hand instruments placed either side of the ectopic (bendint the antemesenteric side “out”) will often facilitate this task without trauma to the serosa or endothelium. If these manoeuvres fail, I generally insert the aspirator/irrigator device into the tubal incision and “hydro-dissect” the products of conception ballooning them outward where can be grasped with forceps and gently removed.
Careful inspection through the salpingotomy usually confirms complete removal of the products of conception. Aggressive dissection of the implantation site can result in significant hemorrhage. Thus, I occasionally will risk “leaving a little” in preference to taking too much tissue. This is particularly true for extraluminal pregnancies. Additional bleeding, while rare, can be controlled with electrosurgical techniques if necessary, preferably a narrow-tipped bipolar forceps. The wound is left to heal by secondary intention unless it is unusually long when one or two interrupted sutures of 4-0 delayed absorbable synthetic suture may be placed to create opposed surfaces.

Specimen removal is generally simple. I recommend placement of an 11mm ancillary port that facilitates intact removal of the gestation without the fragmentation into the pelvis that usually occurs when tissue is removed through smaller ancillary ports. The products may be removed with a “spoon” forceps, other grasping instruments, or via a specimen removal bag. Positioning of the 11mm ancillary port in the midline reduces the likelihood of epigastric vessel injury and is more cosmetically acceptable for most women. While copious irrigation of the pelvis should be performed to remove remaining trophoblastic tissue, I do not make a special attempt to remove all free blood, instead allowing it to be resorbed spontaneously.

Postoperatively, the patient is usually observed for a minimum of six hours prior to discharge. It is imperative that these patients are followed with serial (usually weekly) hCG titers until negative (< 5 mIU/mL). Many series suggest the incidence of persistent ectopic pregnancy is as high as 5%. This is not surprising as Pauerstein et al reported that 33% of all ectopic pregnancies had an extraluminal component. Early detection of a persistent ectopic pregnancy can be easily and safely treated with a single dose of methotrexate (50mg per m² of body surface area) and repeat surgical therapy is only rarely indicated.

Results of laparoscopic salpingotomy
Since the first report of laparoscopic excision of an ectopic pregnancy in 1973 by Shapiro and Adler, over 20 series in greater than 1000 patients have been published. Approximately 95% of cases attempted laparoscopically were successfully completed. Current data suggest that the vast majority (80-90%) of oviducts treated via salpingotomy remain patent and the subsequent intrauterine pregnancy rate is approximately 60%. The repeat ectopic pregnancy rate is approximately 20% and the reported persistent ectopic pregnancy rate is approximately 5%. The incidence of repeat ectopic pregnancy is similar for salpingotomy performed via laparotomy.

SALPINGECTOMY / SALPINGO-OPHORECTOMY
When the affected tube is severely damaged, ruptured, or when future fertility is not desired, a more conservative procedure may not be possible or advisable, making salpingectomy the more appropriate procedure.

If present, the hemoperitoneum is evaculated and adhesions are dissected to mobilize the affected adnexa including the ipsilateral ovary, to provide optimal access to the mesosalpinx.

I prefer to perform laparoscopic salpingectomy with electrosurgical technique maintaining / achieving hemostasis using bipolar forceps such as those designed by Kleppinger. However there are a host of other bipolar designs, and, provided there exists an adequate understanding of electrosurgery, unipolar electrodes can be used with equal
effectiveness and safety. In addition, there exist hybrid devices (see Cutting and Hemostasis, Munro) which contain both a bipolar forceps and a mechanical cutting blade which, in at least some circumstances may justify their additional cost by reducing the time taken to perform the surgery. Every effort should be made to electrocoagulate the mesosalpinx as closely as possible to the oviduct thereby minimizing the risk of thermal damage to the ipsilateral ovary by compromising its blood supply. Serial coagulation of the mesosalpinx can begin either proximal or distal to the ectopic pregnancy and mechanical scissors are used to divide the desiccated pedicle. I generally operate distally to proximally. Following excision of the tube, the specimen can be removed with 10mm grasping or spoon forceps passed through the 11mm suprapubic port. Indeed, use of such a port facilitates removal of the specimen without shearing of the tissue. However, in some instances, it will be necessary to morcellate the specimen or use a specimen bag to remove the tissue.

Salpingectomy may also be performed using pretied surgical loops (Endoloop, Ethicon Inc). If technically feasible, two or three such loops are cinched proximal to the ectopic pregnancy and the tube is excised distal to the ligatures. The mesosalpinx may require additional serial coagulation and excision.

When indicated, salpingo-oophorectomy may also be performed laparoscopically. In such instances, care should be taken to identify the location of the ureter. Bipolar electrodes may be used to coagulate the oviduct proximal to the products of conception. Serial electrosurgical coagulation is performed along the broad ligament avoiding the ureter. The fallopian tube is then resected with laparoscopic scissors and the anterior and posterior leaves of the broad ligament are opened along the margins of the tubal excision. This allows for the identification, electrosurgical coagulation, and transection of the infundibulopelvic ligament. Some surgeons prefer to use endoloops for this step. However, electrosurgical forceps should be available to control residual bleeding along the margins of the incision. With all of these procedures, copious irrigation of the pelvis should be performed to remove any remaining trophoblastic tissue.

**Fimbrial Pregnancy**

Spontaneous extrusion of the products of conception via the fimbriated end of the tubal ostium is occasionally encountered and the abortus can be gently freed from the distal tube without tubal incision. However, “milking” of an ampullary ectopic through the tubal ostium is discouraged due to its high failure rate, propensity for vigorous bleeding, and the potential for mucosal damage with this technique.

**Ruptured Tubal Pregnancies**

The surgical management of frank rupture of the fallopian must be individualized. Patients who demonstrate evidence of hypovolemia are usually best managed by laparotomy. However, when the patient is hemodynamically stable, laparoscopic approaches are clearly feasible. It is important for the surgeon and the surgical team to have laparoscopic suction instruments of suitable design and diameter to facilitate the efficient removal of blood and clots. Should such instrumentation not be available, it may be fashioned out of 10 mm diameter suction tubing, with a port created about 20 cm from the distal end to allow operator control of suction.

Active bleeding may be controlled by the injection of dilute vasopressin into the mesosalpinx, as previously described. However, if such measures are unsuccessful or impossible, there may be no alternative by unipolar or bipolar desiccation followed by
segmental or total salpingectomy. The surgeon must exercise prudence in using the gross appearance of the tube in the acute ruptured state as a predictor of functional outcome. Provided the presence of adequate hemostasis, even extremely damaged appearing tubes may appear surprisingly normal when observed weeks later.

**OVARIAN PREGNANCY**

Ovarian pregnancies are quite rare but may be treated laparoscopically, by medical means, or by combination therapy. Surgical removal is accomplished by dissection of the products of conception from the ovarian parenchyma, similar to an ovarian cystectomy. Dilute vasopressin solution may be desirable. Due to the vascularity of the ovary the surgeon should be prepared and capable of performing an oophorectomy.

**ABDOMINAL PREGNANCY**

Early abdominal pregnancy may also be treated laparoscopically. However, abdominal pregnancies adherent to the liver, diaphragm, or other vascular structure should probably be managed by laparotomy by all but the most advanced laparoscopists.

**INTERSTITIAL PREGNANCY**

A proximal isthmic pregnancy can be treated by laparoscopy. Dilute vasopressin solution is used in liberal amounts. The fallopian tube is incised distal to the ectopic pregnancy and dissection of the mesosalpinx toward the uterus is performed with electrosurgical scissors, needle point electrode, or laser. Due to the potential for significant bleeding with this procedure, laparoscopic treatment of interstitial pregnancy should only be performed by expert endoscopic surgeons in a setting where laparotomy may be performed expeditiously.

**MEDICAL THERAPY FOR ECTOPIC PREGNANCY**

There is a large body of evidence supported the safe and efficacious use of methotrexate for ectopic pregnancy. The clinical settings most appropriate to medical therapy include:

1. Early diagnosis of an unruptured pregnancy
2. Persistent ectopic pregnancy following salpingotomy or salpingectomy
3. Rising hCG titers when no obvious site of the pregnancy can be demonstrated at laparoscopy
REFERENCE LIST


Adnexal Surgery by Operative Laparoscopy

William H. Parker, M.D.
Professor
Department of Obstetrics & Gynecology
UCLA School of Medicine
In women operated on for the presence of an adnexal mass various studies have reported finding malignancy in 7-13% of premenopausal and 8-45% of postmenopausal patients. Preoperative evaluation may help select candidates for operative laparoscopy. Visual inspection of the pelvis and abdomen at the time of laparoscopy may be helpful if obvious signs of malignancy are found. The presence of peritoneal or pelvic excrescences, ascites, or dense adhesions involving a pelvic mass should alert the physician to the possibility of malignancy and laparotomy should be done.

There is now extensive literature available on the use of operative laparoscopy for premenopausal women found to have a pelvic mass. Recent studies have shown good results for operative laparoscopic management of dermoid cysts with low risk of recurrence and only rare evidence of mild adhesion formation seen at second look laparoscopy. Likewise, management of endometriomas by operative laparoscopy has been associated with low risk of recurrence and good fertility rates.

Operative laparoscopy has also been shown to have a role in the management of paraovarian cysts, paratubal cysts and adnexal torsion.

The role of operative laparoscopy in postmenopausal women has been more controversial. Laparoscopic drainage or removal of pelvic masses has been avoided because of the theoretic risk of "spilling" cancer cells into the peritoneal cavity. Dembo and colleagues have presented recent evidence in a large study of 519 patients with stage I epithelial ovarian cancer that the only factors that influenced the rate of relapse were the tumor grade, the presence of dense adhesions, and the presence of large volume ascites. The rate of relapse and prognosis was not influenced by rupture of the tumor.

Recently we published a study in which 22 of 25 (88%) carefully selected postmenopausal patients with adnexal masses were successfully managed by operative laparoscopy. With careful preoperative screening, as described below, we have found benign masses in all 40 postmenopausal patients thus operated upon to date.

Preoperative Evaluation
The patients age, the clinical exam, and ultrasound findings provide important information that help determine the operative approach. Postmenopausal women should also have a serum CA-125 value determined.

Ultrasound
An ultrasound should be performed to determine the size and consistency of the mass. Transvaginal ultrasound is able to achieve greater resolution and clarity of image and is preferred over transabdominal exams.

The presence of irregular borders, papillations, solid areas, thick septa, ascites or matted bowel should raise concern regarding the possibility of malignancy. If suspicious, operative laparoscopic removal is not appropriate and laparotomy should be performed without delay.

Dermoids, endometriomas, hemorrhagic cysts, cystadenomas, and persistent functional cysts will often have a characteristic appearance on ultrasound. Along with the clinical picture and other laboratory data the ultrasound may help select patients that can be approached by operative laparoscopy.
CA-125, a tumor associated antigen, has been studied to determine its value in preoperative differentiation of benign and malignant pelvic masses. Vasilev found that 128 of 132 (97%) patients with pelvic masses who had a CA-125 <35 U/ml had benign masses. Eighty percent of patients over 50 with elevated CA-125 levels had malignant masses. However, in patients less than 50 years old who had an elevated CA-125 value, 34 of 40 patients (85%) had a benign mass. Endometriosis, leiomyomata, adenomyosis, dermoid cysts, and acute or chronic salpingitis may all be associated with elevated levels. Therefore, CA-125 values add to the evaluation of the postmenopausal patient, but they are not helpful in the premenopausal patient.

Combination of Ultrasound and CA-125

The combined use of clinical impression, CA-125 values, and ultrasound findings has been used preoperatively to evaluate pelvic masses in postmenopausal women. Finkler found that all 10 patients predicted to have benign masses were accurately predicted. Using specific ultrasound criteria that suggested a benign mass and normal CA-125 values (Centocor, Malvern, Pa.) we have thus far evaluated 40 postmenopausal patients with adnexal masses and have accurately predicted benign masses in all patients.

Therefore, we feel this combination of criteria constitutes a reasonable selection process in postmenopausal patients. A laparoscopic oophorectomy may be considered if the following criteria are met:

- Ultrasound
  1) a cystic mass
  2) size less than 10 cm.
  3) distinct borders
  4) no irregular solid parts or thick septa
  5) no evidence of ascites or matted bowel

CA-125
  1) Less than 35 U/ml.

General Considerations

All patients scheduled for operative laparoscopy should also be consented for possible laparotomy and the surgeon should be prepared to proceed with staging laparotomy without delay if malignancy is found.

The initial inspection of the peritoneal cavity is done prior to attaching the video camera. We feel this allows better assessment of fine detail and color differentiation. The upper abdomen and pelvis are inspected for obvious carcinoma, excrescences, and ascites. If excrescences are noted they are biopsied and sent for frozen section. If obvious carcinoma, ascites or a positive frozen section is found then we proceed with immediate staging laparotomy through a midline incision.

Once a decision has been made to proceed with operative laparoscopy the video camera is attached allowing the assistant and the nurse to participate. The type of procedure is determined by the operative findings.

Procedures

Aspiration and Fenestration

Aspiration as an isolated procedure is rarely done because it does not allow inspection of the cyst wall or removal of tissue for pathologic analysis. Cytologic analysis of cyst fluid is associated with a high false negative rate. Also, aspiration may be associated with a recurrence rate approaching thirty percent.
Fenestration is the removal of a window from the cyst wall, thus allowing pathologic analysis of a portion of the cyst wall and providing an opening in the cyst for drainage. Aspiration followed by fenestration may be applicable when a cyst less than 5 cms. with benign ultrasound characteristics is found in a premenopausal woman.

Visualization of the entire cyst lining should also be done. If excrescences are found they are biopsied and sent for immediate frozen section.

In most cases of simple cysts we have favored cystectomy since this allows a complete pathologic analysis of the cyst wall.

Procedure
The ovary is stabilized by grasping the utero-ovarian ligament with an atraumatic grasping forceps. An 1 cm. avascular site is chosen on the cyst and the tissue blanched with the point endocoagulator at 120 degrees for hemostasis.

Using the five millimeter aspirating needle via a suprapubic trocar the cyst is punctured and the contents aspirated with a syringe and saved for cytology. The cyst wall is incised along the endocoagulated area with the hook scissors. The irrigating instrument is used to fill the cyst with Ringer's lactate. The optics are inserted inside the cyst and the lining is inspected for excrescenses or solid parts. Excrescences should be biopsied and sent for frozen section. If the cyst lining is smooth it is endocoagulated in its entirety with the point coagulator at 120 degrees. This destroys the epithelium, thus decreasing the possibility of recurrence. A 1 cm. by 1 cm. window of tissue is cut from the ovarian capsule with the hook scissors and the removed tissue is sent for pathologic analysis. The edges of the remaining cyst wall are then endocoagulated to decrease bleeding and eliminate exposed raw surfaces.

Fenestration of the cyst wall, which allows drainage until the ovary heals, has been shown to decrease recurrence.

Cystectomy
This technique may be used for removal of dermoids, functional cysts, hemorrhagic cysts, and endometriomas.

Procedure
The utero-ovarian ligament is grasped with an atraumatic grasper and rotated laterally to expose the ovary. The antimesenteric portion of the ovarian capsule is then endocoagulated in a line approximately one half the length of the cyst.

Using the hook scissors the ovary is then incised superficially along the endocoagulated area. The edge of the ovarian capsule is then grasped with a 5 mm. needle holder or grasping forceps. If it is difficult to develop the plane between the cyst wall and the ovarian capsule the layers may be separated by injecting Ringer's lactate through an aspirating needle inserted directly under the ovarian capsule. The irrigating instrument, attached either to an aquapurator or a bag of Ringer's lactate within an inflated blood pressure cuff, is inserted between the cyst wall and the ovarian capsule.
Parker

**Adnexal Surgery by Operative Laparoscopy**

Using the high pressure stream and the blunt edge of the instrument the cyst is dissected away from the ovary. This technique is called aquadissection.

The cyst should be kept intact as long as possible, since this facilitates dissection. When the cyst is dissected as free as possible, or when it ruptures, it is then emptied of its contents by repeated suction and irrigation until the effluent is clear. The cyst wall is then grasped with the 5mm. ovarian biopsy forceps and teased away from the ovarian capsule.

Dr. Semm has described a "hair curler" technique which we have found useful. The cyst is twisted around the grasping instrument repeatedly which gently pulls the cyst wall away from the ovary. The cyst can then be removed intact from the abdominal cavity through a 5 or 11 mm. suprapubic trocar. If necessary, the cyst may be grasped with a claw forceps and the trocar slid out of the incision allowing more room for removal. If too large the cyst may be bisected prior to removal.

After removal the cyst should be carefully inspected for papillations, septa or thickening of the wall. If suspicious for malignancy it should be sent for frozen section. If malignancy is found the surgeon should immediately proceed with laparotomy.

Excess ovarian tissue may be trimmed so that the edges of the ovary approximate each other. The internal portion of the ovary is then endocoagulated with the point endocoagulator at 120 degrees for hemostasis. Endocoagulating the raw edges causes them to invert and may decrease adhesion formation.

There is some experimental evidence that suturing the ovary increases the likelihood of adhesions. Therefore, this is done only when the ovary can not be reapproximated by endocoagulation alone. We have found the intra-abdominal instrument tie with 4-0 Dexon to be most effective. As few sutures as possible are used.

The abdomen is then copiously irrigated with Ringer's lactate. Suctioning of the sebaceous material found in dermoid cysts is facilitated by warming the solution. This emulsifies the fat allowing it to flow more freely through the suctioning instrument. Hair and other solid tissue is removed with the 11 mm. spoon forceps. Care should be taken to irrigate both the upper abdomen and pelvis. As many as 5 liters of fluid may be necessary.

**Salpingo-oophorectomy**

In premenopausal patients laparoscopic salpingo-oophorectomy may be done in cases where the adnexa is not salvageable. In carefully selected postmenopausal patients, using the strict criteria described above, the adnexa may be removed for complete pathological diagnosis.

**Procedure**

An 11mm. trocar is placed in the midline suprapubically and a 5 mm. trocar placed laterally on the side of the adnexa to be removed. Pelvic washings should be obtained and saved for staging should a malignancy be found. For safety, the ureter should be visualized near the infundibulopelvic ligament.

If a cyst is present needle aspiration is done carefully to minimize spill. The adnexa is then grasped with the 11 mm. claw forceps and pulled medially to expose the infundibulopelvic ligament. The endoloop is then inserted through the lateral 5mm. trocar. The claw is released, passed through the loop and the adnexa is grasped and pulled medially again. The loop is then worked around the tube and ovary toward the
infundibulopelvic ligament. If necessary to properly place the loop an atraumatic grasping instrument may be inserted through an additional contralateral 5mm. trocar. Three endoloops, as per Semm, are placed, sinched down and cut.

With the adnexa pulled medially with the 11mm. claw forceps the 5mm hook scissors is passed through the ipsilateral trocar so that the pedicle may be cut at a right angle to the vessels. Care should be taken to remove the entire ovary while leaving enough of a pedicle to prevent slippage of the endoloop.

The adnexa is then removed via the 11mm. trocar using the claw or spoon forceps. If necessary, it is bissected prior to removal. Immediate frozen section is done if inspection of the adnexa reveals suspicious areas. Frozen section is routinely done for all postmenopausal women.

**Oophorectomy**

This technique may be employed when tubal preservation is desired or if the Fallopian tube has been previously removed.

**Procedure**

Three endoloops, as described above, are placed around the mesovarium and tightened. An additional instrument is used to hold the tube away from the loop, thus preventing inadvertent tubal injury. The ovary is separated from the pedicle with the hook scissors. It may then be morcellated or bissected prior to removal through the 11mm. trocar.

**Salpingectomy**

Removal of the Fallopian tube is indicated in patients with a large hydrosalpinx, an ectopic pregnancy with a diameter greater than 5 cm or a ruptured ectopic pregnancy.

**Procedure**

The proximal portion of the tube near the cornua is endocoagulated with the crocidile endocoagulator and cut with the hook scissors. An endoloop is then placed in this space, then carried around the entire tube and sinched down. The mesosalpinx distal to the endoloop is then incised taking care to leave an adequate pedicle. The tube is then removed through the 5mm. trocar.

**Retroperitoneal Paraovarian cysts**

Most commonly found in women of reproductive age two percent of paraovarian cyst have been reported to be malignant. Strict ultrasound criteria, as used for ovarian masses above, should therefore be applied prior to surgery.

**Procedure**

The peritoneum over the cyst is endocoagulated until blanched and then incised with a hook scissors, away from the fimbria of the fallopian tube. Aquadissection is used to separate the peritoneum from the underlying cyst wall. Aspiration, incision and inspection of the cyst wall are then done as described above.

The cyst is then removed by the hair curler technique. It may be necessary to endocoagulate and excise adherent tissue near the base of the cyst prior to removal. Bleeding areas in the cyst bed are controlled with the endocoagulator. The peritoneal defect is left open.
Management of Adnexal torsion

Early laparoscopic intervention may offer the opportunity to untwist a torsed adnexa prior to irreversible tissue damage.

Procedure

A probe or grasping forceps may be used to untwist the adnexa. If observation reveals a return of circulation to the tissue the adnexa may be preserved. Often the torsion is the result of some pathology, i.e.- an ovarian or paratubal cyst, which should then be treated by the appropriate procedure.

If the tissue is irreversibly damaged as evidenced by lack of circulation it should be removed by the endoloop technique as described above.

Minilaparotomy

In some cases difficulty may be encountered during the procedure and it may be prudent to convert the operation to a minilaparotomy. When done in a limited fashion, minilaparotomy is associated with only slightly greater morbidity and hospital stay than with operative laparoscopy. Rather than persist with a difficult laparoscopy this may provide a viable alternative.
Suggested Reading


LAPAROSCOPIC FERTILITY-PROMOTING PROCEDURES and ENDOMETRIOSIS

Victor Gomel, M.D.
Professor
Department of Obstetrics and Gynecology
Faculty of Medicine
University of British Columbia, and
The Vancouver Hospital
Vancouver, B.C. Canada

Malcolm G. Munro, M.D.
Professor
Department of Obstetrics and Gynecology
School of Medicine
University of California, Los Angeles
Los Angeles, California, U.S.A.
Introduction

Laparoscopy was introduced into gynecology primarily as a diagnostic tool. Its dissemination among gynecologists of the English-speaking world was largely because of its application to the performance of tubal sterilization. The enthusiasm for laparoscopic sterilization did not initially extend to other operative procedures. However, in recent years, laparoscopy has gained universal acceptance as an operative modality (Gomel 1989). The universal acceptance of operative laparoscopy was slow in coming and many of the techniques were developed in the 1970's by a handful of workers (Gomel 1975, Gomel 1977, Mettler et al 1979). Laparoscopic procedures to promote fertility in women were amongst the first to be reported.

This chapter will review periadnexal adhesive disease, distal tubal occlusion, and discuss, in detail, the techniques of laparoscopically directed salpingo-ovariolysis, fimbrioplasty and salpingostomy.

Periadnexal Adhesive Disease

Pelvic and especially periadnexal adhesions are usually secondary to pelvic inflammatory disease (PID). Another infectious cause is acute ruptured appendicitis. Adhesions resulting from operative procedures can be extensive and are usually more cohesive and dense in nature than are adhesions due to PID. Adhesions associated with endometriosis are usually encountered in the more extensive stages of this disease. Detailed discussion of the pathogenesis of such adhesions is not in the purview of this chapter.

While periadnexal adhesions usually accompany other occlusive tubal conditions, they may be present in the absence of any apparent tubal disease. In such instances, adhesions, by enveloping the fimbriated end of the tube, the ovary or both, may prevent the transport of the oocyte into the fallopian tube. In other instances, adhesions, even localized, may distort the normal anatomic relationship between the tube and ovary, and thus impair fimbrial ovum pickup.

Adhesions are composed largely of connective tissue and contain a variable degree of vascularity. Consequently, the appearance of adhesions covers a spectrum ranging from those that are filmy or thick and relatively avascular, to those that are richly supplied with blood vessels. Adhesions may also vary in their cohesiveness, that is, the amount of space that exists between the structures abnormally joined and the density of the adhesive process. Highly cohesive adhesions leave virtually no space, or "slack", between the abnormally attached structures; this adhesive process is usually very dense. "Fatty adhesions" are, in fact, omentum or appendicae epiploica that have adhered to an organ or the parietal peritoneum.

Salpingitis may also cause varying degrees of distal tubal occlusion. Agglutination of the fimbriae may produce phimosis of the distal tubal opening which may or may not be covered by fibrous scar tissue. In other instances the distal tube may be totally occluded (hydrosalpinx) in which case the ampulla exhibits varying degrees of dilation. Such distal tubal occlusions are usually associated with periadnexal adhesions.

Instruments

Modalities for Cutting

Transection via laparoscopy may be accomplished with scissors, electrosurgery, or laser energy.

Scissors

Laparoscopic scissors are used principally to effect mechanical division, even when they possess electrosurgical capability. Since the introduction of laparoscopic techniques, scissors have been our cutting instrument of choice in salpingo-ovariolysis and other fertility-
promoting procedures of the oviduct. Although laparoscopic scissors are now available in a
number of models, the most important characteristic required is their ability to cut effectively,
an attribute that is frequently elusive. Indeed, the maintenance of scissors is difficult. This
partially relates to the disproportionate ratio between the length and calibre of the instrument
which largely negates any beneficial effect yielded by sharpening. These characteristics led to
the development of disposable scissors. We are, in general, philosophically opposed to the use
of disposable instruments, largely because of cost/benefit considerations. However, we believe
that because of the difficulties associated with their maintenance in good working order, that a
strong argument can be made in favor of disposable or reusable-disposable scissors.

The hooked scissors provide certain advantages. They allow the operator to lift an
adhesion away from adjacent tissue before cutting it; the pointed tip provides ease of entry into
the fallopian tube. It is important however to select a type of hooked scissors the points of
which do not overlap when the jaws are closed. Overlap of the pointed tip(s) may be
dangerous when the scissors are employed in retraction, dissection or left unattended within the
peritoneal cavity.

Laparoscopic operative instruments must be improved. This is largely a matter of
engineering and undoubtedly more functional instruments will be available in the foreseeable
future.

Electrosurgical Instruments

A sound knowledge of the principles and bioeffects of electrosurgery is mandatory for
the use of this modality. Effective cutting is ideally achieved with the use of low voltage,
continuous monopolar current (cutting mode) and a fine-pointed electrode. Hemostasis is
usually achieved by compression of the vessel while applying the same continuous current, or,
in limited instances, by fulguration, using the modulated, higher voltage "coagulation" current.
"Blended" current provides an additional amount of thermal coagulating effect along with the
cutting action. In adhesiolysis we employ electrosurgery principally to coagulate blood vessels
encountered along the line of mechanical transection, or to stop persistent bleeders at the end of
the procedure. Bipolar current may also be employed for coagulation of blood vessels,
although currently available electrodes are often too wide for tubal microsurgery.

In the late 1970's concerns were raised regarding the use of monopolar current at
laparoscopy because of the risk of inadvertent thermal injury to adjacent organs. However,
with the production of improved electrosurgical generators and instruments and a better
understanding of the principles of electrosurgery, properly employed monopolar surgical
techniques should not cause a greater rate of injury than other modalities.

Lasers

Of the four lasers that have been employed in the pelvis for cutting purposes (CO₂,
KTP, Argon, and Nd-YAG) the CO₂ laser has been the most popular. Because of the
properties of CO₂ laser energy, it cannot be effectively propagated along a flexible fibre.
Consequently, at present, the light beam must be guided into the peritoneal cavity through a
straight, hollow tube (wave guide) which, in some instances, limits direction of effective
delivery.

With the other three lasers, the energy may be propagated along a quartz fibre which
may be bent to direct the beam as necessary. Sapphire tips attached to the fibre of the Nd-YAG
laser allow the surgeon to operate in contact with tissue. However, this system causes greater
thermal damage.

The Argon and KTP lasers have the following disadvantages: their operation requires
water cooling, necessitating the installation of new plumbing into the operating rooms; and
with the available generators the cutting action is associated with greater adjacent thermal
injury than the CO₂ laser.
Other Instruments

The other important instruments used in the performance of fertility promoting procedures include probes, grasping instruments, uterine manipulators, irrigation and suction devices, and, on occasion, needle holders. These are available in different calibers, ranging from 2 mm. to 5 mm. in diameter. Grasping instruments are manufactured in different lengths, and with a variety of jaw and handle designs. It is not the purview of this chapter to describe instruments in detail. The suction irrigation device permits effective lavage of the pelvis. In addition, it may be used for dissection by introducing an isotonic solution under pressure (hydro-dissection). For the purposes of irrigation and pelvic lavage we employ heparinized lactated ringer's solution.

Investigation

In addition to appropriate history and physical examination of the couple, preliminary investigation must include semen analysis and determination of the ovulatory status of the woman. Hysterosalpingography (HSG) and laparoscopy are complementary methods of assessing tubal and peritoneal causes of infertility. Hysterosalpingography should be the initial investigation for uterine, tubal and peritoneal factors. It is our opinion that a properly performed HSG can be of inestimable value, while a poorly performed HSG is of little value to the physician and an unnecessary source of discomfort to the patient. The advantages of the initial HSG include: (1) identification of uterine anomalies and intrauterine lesions, (2) identification of cornual occlusion and/or non-occlusive proximal tubal disease, (3) identification of distal occlusion and assessment of intratubal architecture which is of prognostic significance; (4) the preceding information is of great value in deciding whether or not to perform corrective surgery at the time of the initial diagnostic laparoscopy (Gomel et al 1986). Corrective surgery for distal tubal disease carries a better prognosis in the presence of relatively normal intratubal architecture. Prior HSG demonstrating a normal uterine architecture and tubal patency will encourage the surgeon who discovers periadnexal adhesive disease to proceed with immediate salpingo-ovariolysis. An abnormal appearing endometrial cavity generally justifies diagnostic hysteroscopy, which can usually be performed in the office or clinic setting. Endometrial endoscopy is used to confirm the abnormality, and will allow for procedure planning in case identified lesions are appropriate for hysteroscopically directed surgery. Collectively, such preoperative information will enable the surgeon to request appropriate operating room time for the procedure.

Surgical Technique

The patient is placed in the low lithotomy position which allows ready access to the genital tract from below. The uterine manipulator should be one that allows chromotubation, as well as adequate manipulation of the uterus during the operative procedure. Manipulation of the uterus enhances pelvic exposure and permits the immobilization of the adnexal structure to be operated on and thus facilitates the procedure.

Operative laparoscopy requires the use of multiple puncture technique. We normally employ a 5-7 mm. laparoscope inserted intra-umbilically. Additional punctures are usually placed suprapubically in the midline and the McBurney's point. When circumstances necessitate an additional entry site, it is placed over the left lower quadrant. The separation of the visual and operative axes provided by this technique allows better depth perception, recognizing the loss of binocular vision at laparoscopy. The procedure is performed with the aid of a compatible high resolution camera and video monitor; thus appropriate interaction between the surgeon, assistant and operating room personnel is achieved. We normally locate the television monitor at the caudal end of the patient. Such placement allows a normal visual
orientation to the pelvis and permits all those involved with the case to have a clear view of the screen.

**Fertility Promoting Procedures**

The fertility promoting procedures of proven value include: (1) salpingo-ovariolysis, (2) fimbrioplasty, and (3) salpingostomy. There are now a number of reports of laparoscopic tubotubal anastomosis; this approach must still be viewed as one that should be restricted to those with demonstrated expertise in the techniques described.

**General Principles**

Microsurgery represents the gold standard of reconstructive surgery in gynecology. When such procedures are undertaken laparoscopically it is necessary to emulate microsurgical principles. Infertility microsurgery is a discipline that uses magnification integrated with the philosophy of tissue care designed to minimize trauma (Gomel 1983a). Peritoneal trauma, whether mechanical, thermal or chemical, elicits an inflammatory reaction. This inflammatory exudate contains fibrinogen, which is transformed into fibrin. Fibrin deposition and fibroblastic proliferation are the basis for adhesion formation.

With proper positioning of the patient, appropriate instrumentation, and adequate distension of the peritoneal cavity, excellent exposure can be obtained at laparoscopy. The ability to bring the laparoscope into the vicinity of the area of interest may render exposure even better than that at laparotomy. In addition, the laparoscope provides a degree of magnification.

Since the procedure is carried out within a closed abdomen, in normal conditions, potentially adhesiogenic drying of the peritoneal surfaces is largely prevented. This protective effect of operative laparoscopy may be eliminated by continuous insufflation of high volumes of CO₂ required for the elimination of smoke (plume) generated by the intraperitoneal use of laser energy.

As in microsurgery, few instruments are used during operative laparoscopy. The design of the end effectors and handles of laparoscopic microsurgical instruments has improved substantially over the last few years. However, the length of these instruments with the cannula acting as a fulcrum still increases exponentially the force applied to the tissue generating unnecessary trauma. Laparoscopic microsurgery is still affected by the limitations of
monocular vision, which results in decreased depth perception, and, at least for some surgeons, difficulty in instrument and tissue manipulation. The emerging development of stereoscopic endoscopes provides a potential solution to this problem. An additional limitation of laparoscopic imaging relates to the angle of approaching the tissue under reconstruction. This limitation may be partly overcome by mobilization of the uterus and adnexal regions as well as the use of the uterus to immobilize the adnexa in an appropriate position. Access to a specific area may also be improved by the introduction of rectal or vaginal probes and variations in the horizontal and lateral tilt of the operating table.

Laparoscopy permits intraoperative irrigation and thorough pelvic lavage at the end of the procedure. In addition, when appropriate, dissection of tissues can be facilitated by introducing irrigation fluid under pressure (hydro-dissection).

Despite the development of relatively fine electrodes (both monopolar and bipolar), laparoscopic hemostasis remains relatively crude in comparison to microsurgery. Fortunately, most bleeders encountered during fertility promoting procedures cease spontaneously and on occasion, the use of a very dilute vasopressin solution may be sufficient to overcome the problem.

Another limitation of operative laparoscopy in comparison to microsurgery lies with the precise alignment and approximation of tissue planes. Despite the development of needle holders and suturing techniques, including intra-abdominal suturing techniques (which is our preference), laparoscopic suturing is often awkward and more time-consuming. In view of this limitation and since one invariably uses suture material of at least slightly larger caliber than that used in microsurgery, the tendency is to apply fewer sutures in operative laparoscopy.

Salpingo-ovariolysis

Patients with prior abdominal surgery frequently exhibit adhesions between the omentum and anterior abdominal wall. If such adhesions limit pelvic visualization it is necessary to remove them first. Adhesiolysis in this instance should be carried out at the level of the parietal peritoneum. Whereas the omentum is a fatty organ, at its site of adherence to the parietal peritoneum the adhesive process may be relatively velamentous. Successful lysis of these adhesions will be dependent upon the optimal exposure of the dissection plane. This is accomplished by retraction of the omentum. If the adhesive process is relatively velamentous it will lend itself to mechanical division with laparoscopic scissors. When the adhesive process is more cohesive it will be necessary to carry out dissection along the appropriate plane. The process is not different than that which is carried out at laparotomy.

The first step in salpingo-ovariolysis is to assess the type and extent of the adhesive process and the structures involved. One of the clear prerequisites of surgery is the recognition of structures, especially when the anatomy is distorted. Adherence to this principle reduces unnecessary trauma and avoids complications. Section of adhesions should ideally be performed along the organ that must be freed. Furthermore, adhesiolysis should be carried out one layer at a time, keeping in mind that what superficially appears to be a single layer of adhesion is usually composed of two. Adhesiolysis should be commenced in a well exposed area near the optic. Division must be effected parallel to the affected organ keeping slightly away from the serosa. This is especially important when adhesiolysis is performed with electrosurgery or laser energy since with both of these modalities lateral spread of the thermal energy occurs.

Effective and safe adhesiolysis requires (1) recognition of what lies behind the adhesion, (2) retraction of the adhesion with a probe or traction with grasping forceps applied to the adhesion and not to the target organ. A small incision is made to elucidate what is
behind the adhesion and whether the adhesion is composed of two rather than one layer. Division is accomplished parallel to the organ as indicated earlier. Shallow adhesions are simply divided. Broad adhesions should be removed by dividing them at their outer margin in a similar fashion. Such adhesions are then removed through one of the portals of entry.

We prefer mechanical division of adhesions using laparoscopic scissors and use electrodesiccation only when significant vessels cross the line of section.

Adhesions encountered secondary to pelvic inflammatory disease are usually relatively avascular and readily amenable to mechanical section or excision. Fatty adhesions are usually those related to the omentum or appendiceal epiploicae. When such adhesions are put on the stretch it will usually be possible to visualize a relatively avascular or filmy attachment where the omentum or appendiceal epiploicae meet the serosa of the organ to which they are attached. If the adhesive process is cohesive one should refrain from using any type of thermal energy. It is necessary to make a small incision at the edge of such adhesions and develop a dissection plane either by spreading the jaws of the scissors and/or using hydro-dissection.

The procedure is completed with a thorough pelvic lavage. This process, in addition to removing blood and debris from the pelvis, enables the visualization of persistent bleedsers. These are individually electrodesiccated using an appropriate unipolar or monopolar electrode.

With all fertility promoting procedures, at the close of the operation, we leave 150 to 200 ml of lactated ringer's solution containing 500 mg of hydrocortisone succinate in the pelvis.

**Fimbrioplasty**

Fimbrioplasty refers to the reconstruction of existent fimbriae in a partially or totally occluded distal oviduct. In the majority of such cases periadnexal adhesions are also present in which case salpingo-ovariolysis is carried out first. Stenosis or obstruction of the distal tube may be the result of agglutination of the fimbriae. As a result, the terminal end of the tube may have a phimotic appearance with a degree of patency. Transcervical chromotubation will distend the ampulla prior to the escape of the dye solution. In other instances, the agglutinated fimbriated end is also covered by a fibrous layer that may cause complete occlusion at the site. Less frequently, the stenosis is located at the level of the abdominal tubal ostium located at the apex of the infundibulum (prefimbrial phimosis). When the fimbriated end is covered by a fibrous layer, it will be necessary to incise or excise this layer in order to expose the agglutinated fimbriae. This can be accomplished using laparoscopic scissors or laser or electrical energy. To deagglutinate the fimbriae a closed 2-3 mm alligator forceps is introduced into the fallopian tube through the phimotic opening. The jaws of the forceps are opened within the tube and the forceps withdrawn with the jaws in the open position. This procedure is repeated several times varying the direction of the jaws, until satisfactory fimbrial deagglutination is obtained. With gentle manipulation bleeding is seldom encountered.

Prefimbrial phimosis is best corrected by placing an incision over the antimesosalpingial edge of the fallopian tube from the fimbriated end into the distal ampulla, in order to get beyond the stenotic site. The tube is immobilized and, if possible, a narrow plastic or teflon probe is introduced through the fimbriated end into the ampulla. Using an electroacutainental electrode the incision is commenced at the fimbriated end of the tube and extended into the distal ampulla beyond the site of stenosis. Bleeders on the incisional edges are individually electrodesiccated. A thorough pelvic lavage is then carried out.
Salpingostomy (Neosalpingostomy)

Laparoscopic neosalpingostomy was first reported from Vancouver, British Columbia (Gomel 1977). Although initially mainly employed as an iterative procedure, laparoscopic salpingostomy is gaining wide acceptance for correction of distal tubal occlusion (hydrosalpinx) as a primary approach. This is the result of improvement in techniques, the availability of in vitro fertilization and embryo transfer as a therapeutic alternative, and the recognition of the factors that affect the surgical outcome. These factors are largely inherent to the status to the fallopian tube at the time of surgery.

Since periadnexal adhesions coexist with most cases of hydrosalpinx, salpingoo-ovariolysis constitutes the first phase of the procedure. The next step is a thorough assessment of the distal tube and its relationship with the ovary. It is imperative to determine whether or not the occluded distal tube is free. When the distal tube is free the tubo ovarian ligament is readily visible. In some instances the terminal end of the tube is adherent to the ovary, in which case the tubo-ovarian ligament is not in view. When the distal tube is adherent to the ovary it is necessary to free the tube from the ovary prior to performing a neosalpingostomy.

We have generally preferred a salpingostomy technique that attempts to imitate the proven microsurgical approach (Gomel 1978). The tube is distended by transcervical chromotubation. This confirms patency of the proximal tube up to the distal occlusion site. It also facilitates identification of the scars at the terminal end of the tube, which usually extend from a central dimple in a cartwheel configuration. The central dimple is entered with the pointed tips of the scissors (or electrosurgically using a needle electrode). The first incision is carried out towards the ovary to form a new fimbria ovarica. Once thus entered it becomes possible to view the tube from within and to fashion additional incisions along the circumference of the tube over avascular regions (over the scarred areas). This is achieved by grasping the tube at the edge of the initial incision, retracting the tube and folding it slightly backward. Additional incisions are then placed appropriately using the scissors (or needle electrode). Viewing the tube from within will permit these incisions to be made along the circumference of the tube over avascular regions, avoiding transection of the vascular mucosal folds. Preservation of these folds is essential to maintain the ovum capture potential of the oviduct. Once a satisfactory neostomy is obtained it is possible to achieve eversion of the edges by the application of two or three 5-0 or 6-0 synthetic absorbable sutures. Eversion of the tubal edges can also be accomplished by focal and superficial shrinkage of the serosa proximal to the ostium, using either electodesiccation or a defocused CO₂ laser beam. It should be noted that there is no evidence to suggest that any eversion technique improves the outcome.

Other successful laparoscopic neosalpingostomy techniques have been described. Gomel first described a technique using long alligator forceps, that, following the creation of a small stoma, is similar to that described above for fimbrioplasty. An "intussusception" method was described by McComb and Paleologou (1991) that is characterized by minimal to modest dilation of the neostoma, followed by a technique of eversion of the distal oviduct that usually stays in place without the aid of suture. Others have reported the use of the CO₂ laser to effect the dissection of the occluded distal tube.

Retrograde Salpingoscopy

Prior to fimbrioplasty, or once the tube is entered in the region of the central dimple, it is possible to inspect at least the ampullary epithelium using a narrow, rigid or, preferably, a flexible endoscope introduced through one of the laparoscopic cannulas. A narrow caliber
hysteroscope (including the sheath), a modified ureteroscope with a through lumen, or other similar device is inserted into the distal tube with the aid of an atraumatic forceps. Distending the tube with lactated Ringer's solution, it is possible to inspect most of the ampullary portion of the tube, and, depending upon the diameter of the endoscope, at least part of the isthmus. In the face of extensive endosalpingial damage there may be an argument in favor of performing a salpingectomy. However, short of extensive intratubal adhesions, it may be appropriate to complete the salpingostomy since the mucosa may regenerate and since intrauterine pregnancies have occurred in the face of apparently severely damaged oviducts. The information provided by the salpingoscopy may influence the decision to proceed with IVF sooner rather than later. Some have advocated the use of transcervical salpingoscopy, prior to laparoscopic or abdominal surgery, thereby triaging patients either to tubal surgery or IVF and ET depending upon the degree of endosalpingeal damage. While promising, the utility of such an approach has yet to be determined.

**Results**

There is a paucity of data analyzing the relationship of adhesions to pain and/or the impact of adhesiolysis on such symptoms. Consequently, we will review only the data relating therapy of adnexal adhesive disease and infertility.

For any type of infertility therapy, the results of clinical investigation may be presented and interpreted in a number of ways. When infertility is presumed or known to be secondary to tubal disease, patency and total pregnancy rates are often suggested or reported as appropriate measures of outcome. However, patency does not equal conception, many gestations are ectopic in location and not all intrauterine pregnancies result in a living baby. Consequently, for the patient and her physician, the only acceptable target is the successful delivery of a healthy baby.

Critical evaluation of the impact of laparoscopic procedures requires distinction between pregnancies that are clearly the result of surgery from those that occur despite such intervention. When surgery is performed on women in whom infertility is secondary to tubal disease that completely occludes both oviducts, subsequent pregnancies may be appropriately attributed to the procedure. However, when there is pre-existing unilateral or bilateral patency, even "partial" in nature, pregnancy could occur without surgery. Consequently, studies evaluating the effect of laparoscopically directed tubal surgery on women with pre-existing tubal patency that do not have control groups, can overestimate the therapeutic effects of the intervention.

**Salpingo-ovariolysis**

Gomel (1975) provided the initial report on laparoscopic salpingo-ovariolysis and fimbrioplasty. Of the whole group of 39 patients one was lost to follow up and three, for various reasons, avoided a pregnancy. Fourteen patients achieved one or more intrauterine pregnancies. Among the 24 patients followed for a year or more the intrauterine pregnancy rate was 59 percent. In 1979, Semm's group from Kiel reported on salpingolysis and ovariolysis (Mettler 1979). The total pregnancy rates were 38 and 21 percent respectively. However, the location and outcome of these pregnancies was not stated. Gomel (1983b) reported a series of 92 patients who underwent laparoscopic salpingo-ovariolysis. Thirteen of these had moderate while 79 had severe periovarian adhesions, and all had experienced at least 20 months of infertility. After a follow-up period of at least nine months, 57 (62%) had conceived, 54 (59%) with an intrauterine pregnancy. Half of these women conceived within six months of surgery. Following this report four additional patients delivered healthy infants.
Corroborative outcomes were reported by Fayez (1983) and Bruhat et al (1983). They attained intrauterine pregnancies in 56 percent of 50 and 52 percent of 93 patients respectively. Donnez et al reported similar results in 1989.

We must draw attention to the ectopic gestation rates in the preceding reports that ranged between 4 and 7.5 percent of operated patients. These rates suggest that periadnexal disease is not an isolated entity and that, in a proportion of cases, it is associated with significant damage of the tubal endothelium.

**Fimbrioplasty**

Relatively few investigators separately classify and report cases where fimbrioplasty is performed. Among 40 patients reported by Gomel (1983c), 19 (47.5%) had successful deliveries and two had ectopic gestations. The Kiel group (Mettler 1979) reported a 31 percent pregnancy rate among 51 women, although again, the location and outcome of these pregnancies was not revealed. Dubuisson et al (1990) reported intrauterine and ectopic pregnancy rates of 25.8 percent and 12.9 percent respectively, in 31 women followed for 18 months. Surprisingly, these results were inferior to those yielded by their salpingostomy group. No patient conceived between 12 and 18 months. More recently, Canis et al reported intrauterine pregnancies in 16 of 32 patients (50%) treated by laparoscopic fimbrioplasty, but did not provide further details regarding the pregnancy outcomes. None of these studies are controlled, but collectively the results are similar to those reported when fimbrioplasty is performed at laparotomy with microsurgical technique.

**Salpingostomy**

Demonstration of the efficacy of surgery for bilateral tubal occlusion is not dependent upon controlled studies, since virtually all subsequent spontaneous pregnancies may be attributed to the intervention. However, of interest are the outcomes when salpingostomy by laparotomy and laparoscopy are compared. The comparison of results has been facilitated with the introduction of the American Society of Reproductive Medicine's (ASRM) classification system for prognostic factors. These include the distal ampullary diameter, the thickness of the tubal wall, the status of the oviduct's endothelium, and the nature and extent of coexistent adhesions.

Laparoscopic salpingostomy was initially reported by Gomel in 1977; four of nine patients conceived, all with successful pregnancies. Of note is that eight of these women had previous conventional salpingostomy via laparotomy with subsequent re-occlusion of the tube(s).

Mettler et al (1979) reported 10 pregnancies among 38 patients after laparoscopic salpingostomy with the use of thermal coagulation. The location and outcome of these pregnancies were not specified. Daniell and Herbert reported on 22 patients in whom salpingostomy was performed using CO\textsubscript{2} laser via laparoscopy. Four patients achieved intrauterine pregnancies, one of which was aborted; one patient had a tubal pregnancy.

Dubuisson et al (1990) reported 10 uterine pregnancies (29.4%) and only one tubal pregnancy among 34 patients after laparoscopic salpingostomy. McComb and Paleologou (1991) reported five term pregnancies in 22 patients followed for more than one year treated by the intussusception method. One patient had an ectopic gestation.

Canis et al (1991) reported intrauterine pregnancies in 29 (33.3%) of 87 patients, while six experienced ectopic gestation. These authors classified their patients into four groups depending upon the severity of the tubal damage. The fallopian tubes in the most favourable group (32 patients) are described as having "partial occlusion (phimotic tube)". This group,
which yields the best outcome, is in effect a fimbrioplasty group. Of the 55 remaining patients with complete distal occlusion, 13 (22.8%) achieved an intrauterine pregnancy while six (10.9%) had ectopic gestations.

While little is known about the relative efficacy of the various techniques described. Oh, from Korea, recently published a comparative study of eighty-two women allocated (in a non-randomized fashion) to one of three techniques: (1) A neosalpingotomy similar to that described in detail earlier in this chapter, but using scissors; (2) creation of a stoma electrosurgically followed by electrosurgical coagulation of the serosa to obtain eversion; and (3) the intussusception method modified by the routine use of suture for eversion. While the patients were not randomized, they had similar modified ASRM prognostic scores. At hysterosalpingogram two months later, patency rates for types 2 (23/27 - 85.1%) and 3 operations (28/29 - 96.2%) were significantly greater than that for the type 1 procedure (13/26 - 50%). The overall rates of intrauterine conception were 19.2%, 37.2% and 48.2% respectively, and were even higher in women with favorable prognostic scores (30%, 54.5%, and 64.3%).

Gomel has reported intrauterine pregnancy rates in women undergoing neosalpingotomy performed at laparotomy with microsurgical technique (1990). Of 73 patients with poor prognosis, 13 (18%) achieved an intrauterine pregnancy while 12 of 17 (71%) with good prognosis were successful.

**Tubotubal Anastomosis**

Anastomosis of the mid portion of the oviduct is most commonly performed to reverse a previous tubal sterilization and rarely to treat pathologic occlusion. Laparoscopic approaches to tubotubal anastomosis must be held to the high standard set by laparotomy-based microsurgical techniques. Such approaches have been considered to be the ideal application of reconstructive microsurgery in gynecology for they permit meticulous apposition of tissue planes and yield excellent results (reported live birth rates vary between 60 and 80 percent). Furthermore, microsurgical repair may be accomplished with a minilaparotomy technique, that, with generous but appropriate post operative local anesthesia can allow early discharge from hospital. As a result, the laparoscopic approach to tubotubal anastomosis remains to be proven as an appropriate alternative.

**Technique**

The principles of tubotubal anastomosis are well known and have been extensively described (Gomel 1983). First, the occluded segment of tube is excised, fashioning the incision so that normal appearing oviduct is identified. While hemostasis must be secured, it is important not to compromise the tubal vasculature. The cut edges are then aligned accurately and joined with fine, minimally reactive suture.

After the induction of satisfactory anesthesia, the patient is placed in the low lithotomy position using appropriate supportive stirrups. An articulated uterine manipulator, that allows chromotubation, is inserted into the endometrial cavity and affixed to the uterus. After establishing the pneumoperitoneum and satisfactory positioning of the laparoscope, three ancillary cannulas are positioned in each lower quadrant, and suprapublically in the midline. Following detailed examination of the fallopian tubes, necessary salpingo-ovariolysis is performed. The proximal segment of the tube is distended by chromotubation and the occluded end is grasped with fine laparoscopic forceps. Through another laparoscopic cannula, fine scissors are used to transect the tube at right angles, starting at the antimesosalpingeal border, but stopping short of the vascular arcade. The lumen will be identified when the dyed solution escapes. The magnifying capability of the laparoscope is used to inspect the lumen,
endothelium and muscularis to confirm that the tissues appear healthy. If abnormal tissue is suspected or identified, serial incisions are made until normal healthy appearing tissue is identified. For isthmic-isthmic anastomosis, a similar approach is used for the distal segment of the tube, with patency confirmed with the insertion of a fine polyethylene catheter and the injection of dye.

The occluded portion(s) of tube that remain are now freed from the mesosalpinx using a needle-tipped microelectrode attached to an appropriate electrosurgical generator set to pure, low voltage continuous alternating (cutting) current. The excised tissue is removed through one of the laparoscopic cannulas. Hemostasis in the muscularis is achieved with electrodessication using the microelectrode; endothelial oozing is generally self-limited and is therefore managed expectantly.

Isthmic-ampullary anastomosis provides a challenge due to the disparity in luminal diameter. Instead of tangential transection, a suitable stoma must be fashioned. First the distal stump is distended following insertion of the polyethylene catheter through the fimbriated end. Then the fine scissors are used to incise the serosa, exposing the underlying muscularis. The muscularis is regrasped and the scissors are used to create an opening with a luminal diameter similar to that of the proximal tubal segment.

Both isthmic-isthmic and isthmic-ampullary anastomoses are completed in a similar fashion. Fine suture (7-0 braided, synthetic absorbable) swaged to a 3/8 curved needle is inserted through a cannula and held by a curved microsurgical needle driver. The initial suture is critical to alignment and is placed at 6 o'clock, near the attachment of the mesosalpinx, including both the muscularis and the epithelium. The knot is tied with intracorporeal technique and is kept external to the tubal lumen. Additional sutures are positioned and tied in a similar fashion, their number dependent upon the caliber of the tubal lumen. Upon completion of this step, patency is confirmed with transcervical chromotubation. The serosa and mesosalpinx are repaired with interrupted and/or continuous sutures of the same material. If necessary, the same technique is performed on the other side. Pelvic lavage completes the procedure, which has also been demonstrated by Koh and Janik in videotape (1993).

In an attempt to reduce operating time related to suturing Sedbon et al and Auld et al have reported the insertion of tubal stents, either by laparoscopy or hysteroscopy, followed by joining the segments with a type of biological glue (Tissucol Immuno Laboratoire France).

Results

Relatively few results of laparoscopic tubotubal anastomosis have been reported to date. Reich et al reported that six of 22 women had at least one pregnancy while three had at least one tubal ectopic gestation. Their procedure differed from those described above in a number of potentially important ways: 4-O or 6-O suture material was used; only two such sutures were used and these included the serosa, muscularis and endothelium; only one tube was repaired per patient. Operating times ranged from 65 to 240 minutes.

Sedbon et al did not report any pregnancies with tissue glue apposition while Auld et al described two of six patients with intrauterine gestations and one with an ectopic pregnancy. For both groups of patients, only one tube was anastomosed.

Conclusions

Pelvic and periaudnexal adhesions arise as a result of an inflammatory process secondary to infection, endometriosis, and physical or chemical trauma. They are most frequently encountered in association with infertility or pelvic pain. With appropriate planning, case selection, instruments and technique, periaudnexal and pelvic adhesions and distal tubal occlusion can be treated laparoscopically in a safe and effective manner. The results obtained
by laparoscopically directed salpingo-ovariolysis and fimbrioplasty approach or equal those obtained by microsurgery. The advantages afforded by the described procedures that can be performed at the time of the initial diagnostic laparoscopy are evident. The results afforded by laparoscopic salpingostomy may be slightly lower than those yielded by microsurgery. However, the principal determinant of the outcome is the status of the tube at the time of surgery. The following factors influence the outcome: (1) distal ampullary diameter, (2) tubal wall thickness, (3) nature of the tubal endothelium at the neostomy site, (4) extent of adhesions, and (5) type of adhesions. These factors have been quantified in a scoring system which permits estimation of the likely surgical outcome (Gomel 1988). Considering that improvements in the results of salpingostomy with the use of microsurgical techniques have been much less impressive than for other tubal reconstructive procedures, considering further that IVF offers a credible alternative therapeutic option, there is a greater place today for laparoscopic salpingostomy in appropriately selected cases, especially since this procedure can be performed during the initial diagnostic laparoscopy.

At the present time the reported results of laparoscopic tubotubal anastomosis do not approach that of traditional microsurgery. Nevertheless, with time, and the development of adequate surgical technique and skill, it is likely that these results will improve.
References

Laparoscopic Hysterectomy

Malcolm G. Munro M.D.
Professor
Department of Obstetrics & Gynecology
University of California, Los Angeles
Los Angeles, California
Laparoscopic hysterectomy (LH) was introduced to offer the patient a therapeutic option to abdominal hysterectomy (AH). The procedure was offered to be less expensive, less painful and associated with an improved cosmetic result, all without increasing the rate of complications. Currently, many consider LH to be of limited value at best, and at worst an expensive exercise, prone to increased morbidity and therefore destined for the surgical waste heap. Others view the procedure to have revolutionized our surgical approach to the performance of hysterectomy.

A critical evaluation of this new procedure is timely, as the use of laparoscopy to aid or direct hysterectomy has come in an era characterized by socioeconomic change. The impact of these changes is an important consideration when discussing the role of any medical or surgical intervention. The role of women in contemporary society has changed from one characterized by widely perceived subservience and fiscal irrelevance, to one of real equality and increased economic responsibility. Consequently, recommendations or procedures that have economic consequences, whether they be bed rest or surgery, are now more likely to be held up to patient scrutiny. The economic impact of care decisions is also a particular target of third party payors who are increasingly attempting to reduce the cost of providing care for their clients. Furthermore, the place of hysterectomy itself has been challenged, as increasing numbers of women now select expectant, medical or minimally invasive surgical approaches for the management of many benign conditions, instead of subjecting themselves to removal of the uterus.

When hysterectomy is necessary, it is critical to identify the technique that accomplishes the task while imparting the least degree of morbidity at the lowest possible cost. Minimally invasive surgical strategies have the potential to reduce both the direct cost of providing care, and the indirect cost associated with the temporary removal of a productive individual from the workforce. Unfortunately, current reimbursement methodology is not designed to reward reduction in indirect costs, for the third party payor does not (at least currently) share in any such savings.

Vaginal hysterectomy (VH) was the first minimally invasive surgical approach to removal of the uterus. It is now apparent that the vaginal approach, when compared with AH, provides an opportunity for earlier discharge than previously thought possible. In some centers, with suitable support from home care personnel, patients may be discharged home as soon as the day of surgery. Furthermore, while VH is similar to LH from the perspective of morbidity, it is less expensive with respect to cost. Consequently, it seems that those women who are candidates for VH should not undergo LH, unless unexpected surgical findings preclude completion of the operation by the vaginal route.

AH remains the only uterine extirpative procedure where the inherent morbidity of laparotomy prolongs both the operative stay and the subsequent return to normal activity. These factors combine to result in increased cost of care, compared to VH. The formation of a large abdominal incision adds pain, the opportunity for wound complications, and leaves a cosmetic result that, for most at least, is less desirable than is the case for either VH or LH. It seems obvious, therefore, that if LH has a place, it is for patients who would otherwise require a laparotomy-based procedure. However, to be of real value, the morbidity associated with the LH must indeed be less than that associated with AH, and the cost must be acceptable to the patient and/or her third party payor.
Munro Laparoscopic Hysterectomy

WHAT IS LAPAROSCOPIC HYSTERECTOMY?

The performance of laparoscopic hysterectomy was first described by Reich in 1989. Any discussion of LH requires a definition of the procedure itself. In fact, the operation is a spectrum of procedures that range from vaginal hysterectomy facilitated by the performance of laparoscopically directed adhesiolysis, through laparoscopic dissection and division of some of the uterine vascular and ligamentous attachments, to total removal of the uterus under laparoscopic direction. A classification system describing these variations has been published.

The amount of laparoscopically directed dissection required before the uterus can be removed vaginally will vary according to the patient, the location and extent of pelvic pathology, and the relative abilities of the surgeon with laparoscopic and vaginal technique. Such variation in the technical aspects of the procedure could have a profound impact on operating time and morbidity, and, consequently, upon cost. In general, surgeons are advised to operate under laparoscopic direction until they can complete the procedure vaginally. In some procedures, the laparoscopic component may be limited to evaluation of the pelvis or division of adhesions sufficient to allow the entire procedure to be performed laparoscopically (Type O). A greater degree of complexity is added if the triple pedicles are occluded and divided laparoscopically or if infundibulopelvic ligaments are taken under laparoscopic direction to accomplish removal of the ovaries (Type I). If adequate descent is not obtained, or, if, for example, posterior cul-de-sac obliteration is encountered, there will be a requirement for more extensive laparoscopic dissection including the uterine arteries (Type II) or part or all of the cardinal-uterosacral ligament complex (Types III and IV). Closure and suspension of the vaginal cuff may be accomplished by vaginal and/or laparoscopically directed techniques. Laparoscopic subtotal, or supracervical hysterectomy has been described, but its appropriate place has not yet been defined.
Munro  Laparoscopic Hysterectomy

IS LAPAROSCOPIC HYSTERECTOMY SAFE?
In the six years since its introduction to the medical literature, LH has been the subject of a number of published observational series \(^7-13,\ 15-19,\ 21\) and comparative studies \(^2,\ 14,\ 20,\ 22-24\). These are collated in Figure 2. From this literature, it can be seen that laparoscopic hysterectomy can be performed safely, with complication rates similar to those encountered with either the vaginal or abdominal routes.

In studies where complication rates seem higher than anticipated, and where there is data regarding the training or experience of the surgeons \(^3,19\), it is apparent that there is a preponderance of poorly trained surgeons performing LH. In the Boike paper from Northwestern, the average surgeon had apparently performed a total of 2.8 procedures (including those in the study), 13 performed one only, while only four completed five or more laparoscopic hysterectomies. Four surgeons performed their first LH unsupervised. Despite this rather poorly trained and inexperienced group of surgeons, the complication rate with LH in this center was far less than that of a comparison group undergoing TAH. In the Seattle review, the complication rate was 60\%, again with surgeons early on the learning curve. The literature contains only a few additional reports of ureteric obstruction following the use of linear cutting and stapling devices \(^16,25\) although the author is aware of many more unreported episodes of ureteric injury. In the published series, while there are occasional episodes of bladder entry and bowel trauma \(^11,17,19,21\) most were repaired under laparoscopic direction, thereby minimizing the impact of the complication. In addition, the frequency of these major complications seems comparable to that expected when TAH is performed.

It could be argued that the literature more likely presents a measure of the efficacy of LH, or the clinical outcome expected at this time from those with above average or superior skill. While such outcomes are unlikely to represent the complication rate experienced in the communities at large (effectiveness), they should represent the potential offered by the procedure. Regardless of the operation and the technique, it is generally accepted that inadequate training will usually result in less than optimal clinical outcome. This may be especially true for laparoscopic surgery where relatively few have had the technical training necessary for procedures that require different and, perhaps, more demanding skills than is the case for the traditional approaches. Consequently, while it is reasonable to conclude that LH is safe and efficacious, it is quite probable that the same may not be said for many laparoscopic surgeons.

IS LAPAROSCOPIC HYSTERECTOMY COST EFFECTIVE?

General Considerations
The cost of the procedure has been a target of those generally opposed to the implementation of LH. The total cost of a medical intervention like LH should be calculated considering all of the expenditures directly associated with the performance of the procedure as well as the total economic savings realized by the patient, her employer and/or the third party payor. It is also important to consider the differences between provider cost and consumer price, the latter a peculiarity of a system where the provider adds a margin of profit for items such as disposable laparoscopic instruments. Failure to appreciate the variable factors that contribute to the cost of LH may result in inaccurate conclusions regarding its economic impact.

The costs associated with LH may be considered as either direct or indirect. Direct costs are those that are paid for the procedure by the patient, her third party payor, or, in a capitated environment, the provider. Indirect costs represent variables like the loss of
Munro Laparoscopic Hysterectomy

income (lost opportunity cost) associated with post-operative recuperation and vary greatly with the occupation and social situation of the patient.

**Variables Affecting Direct Cost**

Direct costs include hospital bills and the professional fees paid to the anesthesiologist, the surgeon and the surgical assistants. Included in the hospital bills are the operating room time, the price paid for disposable instrumentation, the prorated acquisition and maintenance costs of capital equipment and non-disposable supplies and the post-operative length of stay (LOS). While variable with region, health care provider and reimbursement methodology, direct costs are calculable and generally similar for women cared for in the same health care environment.

Most published studies comparing the direct expenses of laparoscopic with abdominal hysterectomy have demonstrated that the laparoscopy-based procedure is more expensive by approximately $1,500 to $4,000\[^{3,4,10,14,20,24}\]. However, in a white paper by the accounting firm of Deloitte & Touche, describing the experience in nine hospitals throughout the US, LH was only $936 (Range $167 to $2123) more expensive than TAH\[^{26}\]. Furthermore, in their analysis of the costs associated with the laparoscopic hysterectomies performed by the most experienced surgeons and surgical teams, the average laparoscopically directed procedure was $352 less expensive (range $-390 to $1333) than TAH. The reason for the differences in the hospital oriented direct costs requires differential analysis of the various components of the hospital bill.

**Operating Room Time**

The duration of operating room utilization will vary with the efficiency of the operating room team, the skill of the surgeon, the difficulty of the case and, in some instances, the available equipment and supplies. In addition, it is important to consider variations in the way that an investigator calculates operating room utilization, for some consider only the surgical time, while others measure the entire time the patient is in the operating theater.

In the current medical literature, the average duration of operating room utilization for LH varies greatly, from 1.3 to 4 hours\[^{2-4,10,13,14,16-18,22-24}\] (**Figure 3**). Most of these reports represent the surgeon's or institution's initial experience with the procedure. The group with the 4.0 hour average operating time is the Northwestern group, described previously. The 29 surgeons performed an average of only 2.8 procedures, 13 performed one, and only four completed five or more laparoscopic hysterectomies\[^{3}\]. Not surprisingly, this was also the group that had the greatest difference in price for the surgery when compared with abdominal hysterectomy ($4000). On the other hand, the best results (1.3 hours) were those reported by a single surgeon who reported 119 consecutive laparoscopic hysterectomies\[^{18}\]. It seems likely that these rather discrepant results are, to a large degree, related to a combination of skill and experience on the part of the surgeon and support staff. This concept of a learning curve affecting operating room utilization seems to be supported by the Deloitte & Touche white paper\[^{26}\] (**Figure 4**). In one institution, over a 12 month interval, the procedure time decreased from just under three hours to just over two hours.

For at least some surgeons, the availability of time saving instrumentation may make an impact on the duration of the surgical procedure. For example, some surgeons report that operative time is decreased with the use of stapling techniques\[^{4}\]. While expensive, if judiciously used, the acquisition costs of these instruments may, in some instances, be offset by the reduction in operating room time. A factor that is currently difficult to estimate is the
Munro Laparoscopic Hysterectomy

disorder specific impact on duration of the procedure. At present, there are no available
type-specific evaluations of LH performed in various pathological conditions. However, an
inference could be made from the Johns and Diamond study, where, using a classification
system based upon degree of laparoscopic dissection, operating time could vary from 52 to
87 minutes depending upon the complexity of the laparoscopic dissection. Such
information could also reflect the impact of a given surgeon's vaginal surgical ability on the
cost of care. Those with less developed vaginal skills will likely increase cost by prolonging
operating room utilization.

Equipment and Supplies

Performance of LH requires a degree of sophisticated equipment and supplies not
needed for laparotomy-based procedures. The most obvious differences are the capital
requirements for cameras, endoscopes, light sources and insufflation machines. Fortunately,
most of these items are relatively sturdy and can be used for many cases, adding only minor
incremental cost to the performance of each procedure. However, the choice of
laparoscopic trocar-cannula systems and hand instruments have a widely varying affect on
the cost (or price) of a laparoscopic hysterectomy.

Disposable instruments can add significantly to the cost and the price of the
procedure, particularly if the hospital doubles or triples the cost of the instrument when
charging the patient or her third party payor. This creates a very great difference in the price
of the operation compared to AH, where there is little opportunity for the provider to make
such profits. On the other hand, if non-disposable cannulas are used, and if the surgeon
secures pedicles with less costly techniques like suture or electrical desiccation, the supply
cost of performing the procedure will be greatly reduced, allowing a corresponding decrease
in price. One group reported a $961 per case reduction in price when they converted from
disposable cannulas, scissors and insufflation needles and tubing to reusable devices.
Further, selective use of reusable instrumentation is possible for all endoscopic surgeons as
familiarity is gained with different techniques for securing pedicles.

There are other factors contributing to a decrease in the supply cost for LH. Market
forces are already resulting in a significant reduction in the acquisition cost of disposable
instrumentation. Such instruments are now at least 50 percent less expensive compared with
the prices reported in the literature. The move to contracted and capitated care is also
affecting the way supply costs are calculated. A procedure's direct economic impact will
more often be reported based upon the actual cost because there will be no opportunity for
the provider to take a profit on the disposable equipment. Since supply cost may comprise
up to one third of the hospital bill, and, given existing markups of two to three times cost, a
significant reduction in LH procedure cost will be recognized.

Length of Stay

The greatest opportunity for LH to decrease hospital-related costs, compared to AH,
is a decreased postoperative length of stay (LOS). In the literature, the average LOS
reported for LH about two days - four days for AH (Figure 3). However, there are some
centers where the length of stay is less than 2 days. In one where the average stay was 1.18
days, 59 of 72 patients were discharged within 24 hours of surgery. Another group
reported consistent discharge home within 12 hours of admission. Considering the cost of
postoperative hospitalization, such variations will significantly impact upon the cost
differences between LH and AH.
Munro Laparoscopic Hysterectomy

There are a number of factors that potentially affect LOS, including operating time, intraoperative complications, patient comfort, surgeon experience and the policies of the third party payors. With the acquisition of institutional and surgeon experience the length of stay generally decreases, in part due to decreased operating room time and in part because of increasing confidence that, in at least most instances, the postoperative stay need not be more than 24 hours. If there is an organized method of communication, combined with home visits if needed, same day discharge is both feasible and safe. All of these factors should result in an even greater decrease in LOS and a corresponding reduction in the direct costs of the procedure. This seems to be supported by the Deloitte & Touche study, where the most experienced groups were actually realizing a decrease in the cost of LH compared with AH with a LOS of 1.5 days. At least in this group of hospitals, shorter stay alone would result in LH becoming considerably less expensive than AH.

Variables Affecting Indirect Cost

For the patient, a significant potential benefit of LH is a faster return to her work compared to TAH. Early return to productivity is economically beneficial to the patient and her employer. The need for employers to hire suboptimally productive replacement staff would diminish, a benefit particularly important to the self-employed individual.

While there are few studies that have specifically addressed this issue, a number have compared LH and AH for return to work or normal activity. In most instances, patients feel totally recovered by two to four weeks following LH and four to six weeks after TAH. One comparative study determined the average return to work to be three weeks following LH and five weeks after TAH. While the measured economic impact will vary depending upon the preoperative income and productivity of the patient, it is apparent that the indirect effect of LH is the reduction in lost opportunity costs, at least for economically productive individuals. Conversely, TAH will increase the overall cost of removal of the uterus for the patient and/or her employer.

It is important to realize that health care insurers do not share in this reduction in indirect cost. This is undoubtedly a significant factor in the reason that laparoscopic hysterectomy does not seem, to the insurer, to provide significant cost advantages.

TO WHICH PATIENTS SHOULD LAPAROSCOPIC HYSTERECTOMY BE OFFERED?

The decision regarding technique will depend, to a large extent, upon the relative abilities of the given surgeon to perform the three procedures; vaginal, abdominal and laparoscopic hysterectomy. Provided that early discharge is offered, VH is less expensive to perform than LH because of reductions in both operating time and the cost of equipment and supplies. Evidence exists suggesting that morbidity and indirect costs may be equivalent to LH. Consequently it seems clear that if VH can be performed, it should be offered to the patient, instead of LH or AH. On the other hand, each case where VH is not possible should be considered for LH, remembering that there are limits to the laparoscopic approach and that hysterectomy via laparotomy will not become obsolete. The most obvious examples are the massively enlarged uterus and at least most instances of gynecologic malignancy. However, it is apparent that LH has at least some place in the management of oncologic patients. The performance of selective laparoscopic lymphadenectomy in association with laparoscopic hysterectomy has resulted in decreased morbidity for selected patients with early stage cervical and endometrial cancer.
Munro Laparoscopic Hysterectomy

Many, including myself, are concerned that practitioners will increase the cost of care by performing LH on patients who, in at least well trained hands, could undergo VH. Hospitals and other patient care institutions should be encouraged to monitor the center-specific impact of LH. Assuming that there is no change in patient or surgeon population, the proportion of hysterectomies performed vaginally should remain the same, while the laparoscopically directed procedures should come exclusively from the pool of patients previously undergoing AH.

WHO SHOULD PERFORM LAPAROSCOPIC HYSTERECTOMY?

Most of the evidence supporting LH as a prudent addition to the armamentarium of the gynecologist is based upon the relatively few, usually highly skilled and experienced surgeons who have submitted their data to the literature. This measure of efficacy is not likely to be reflective of effectiveness, or outcome when the procedure is implemented in the communities by surgeons with lesser skill and training. We have demonstrated evidence from the literature suggesting that complications and increased costs associated with LH are more common when the surgeon is relatively inexperienced and/or poorly trained 3,19,26.

The fact that laparoscopic hysterectomy is, in fact, a spectrum of procedures that possess increasing degrees of surgical complexity is another important issue. The complex technical requirements for the more difficult laparoscopic cases must be counterbalanced by an increased degree of skill at either or both LH and VH. Otherwise, the procedure time may be unduly prolonged and unnecessary conversion to abdominal hysterectomy may be required, with its attendant increase in morbidity and total cost. The surgeon's pre-existing skill at vaginal surgery is important for other reasons. Given that there may be no real advantage of the laparoscopic over the vaginal approach, and that cost of laparoscopic hysterectomy is likely greater, surgeons with lesser vaginal skill will increase the cost of care.

It is clear that training and experience are prerequisites to optimal clinical outcome. It is also clear that the individuals who should perform LH are those with well developed skills in both laparoscopically and vaginally directed removal of the uterus. However, it is difficult to prospectively identify these groups or individuals when there exists no widely recognized formal methods for training, evaluating and monitoring those who would perform LH.

CONCLUSIONS

Laparoscopic hysterectomy is actually a spectrum of procedures designed to reduce the usual morbidity and cost associated with laparotomy-based approaches. It is clear that the operation can be performed safely and probable that the total cost of care can be reduced by its appropriate implementation. The procedure requires an advanced degree of technical skill and judgement on the part of the surgeon and a relatively sophisticated array of equipment and supplies. Surgeons who perform laparoscopic hysterectomy without an adequate degree of training or skill will likely have clinical outcomes that are suboptimal. Those who employ an unnecessarily extravagant amount of expensive disposable equipment and supplies will find that the cost of the procedure is correspondingly increased. Furthermore, while laparoscopic hysterectomy seems to be equivalent to vaginal hysterectomy with respect to morbidity, it may be more expensive. Consequently, those who are not confident with the performance of vaginal hysterectomy will likely increase the cost of care for their patients.
It is my contention that LH, performed by the right surgeons, on the right patients, and with the right facilities and equipment, can deliver on its promise of reduced overall cost and morbidity. Many women will experience reductions in pain, cosmetic trauma and will more quickly return to a productive place in the workforce. There are clearly instances where LH has added to both the cost and the morbidity associated with the performance of hysterectomy. However, in the vast majority of these instances the reason for the increased cost, or morbidity, can usually be linked to one or a combination of three factors: (1) surgeons with inadequate training, ability or judgement; (2) surgeons who are early on the learning curve; (3) unnecessary use of costly equipment or supplies.

While laparoscopic hysterectomy is a technique valuable to the health care of women, it is clear that there are problems with its widespread implementation. Rather than suggest its abandonment, critics should direct their attention to the methods by which such procedures are deployed and monitored in practice, considering training, credentialling and quality assessment. The lack of a rigorous system of training, objective evaluation, credentialling and quality assessment of LH, and other endoscopic and non-endoscopic interventions, is one that women, third party payors and society will not tolerate much longer. Our imperative is to lead in the development of such a system. Consequently, the most pressing question is not "Should laparoscopic hysterectomy be allowed entry into our cadre of accepted procedures?"; but instead, "How do we select, train and monitor those who should perform this new and technically challenging operation?"
REFERENCES


Medical and Surgical Approaches for Uterine Leiomyomas

Malcolm G. Munro MD
Professor
Department of Obstetrics & Gynecology
UCLA School of Medicine
Leiomyomas are extremely common tumors of the uterus, consuming a significant proportion of the resources expended for gynecologic health care. In the fifth decade of life, leiomyomas may be found in more than 25% of caucasian women, and over 40% of women of African ancestry. As for most other neoplasms, the etiology of leiomyomas remains obscure. The tumors arise from the myometrium, are frequently, but not always multifocal, and, have varying clinical implications depending in part upon their number, their size, and their location with respect to the uterine structure. While it has been assumed for decades that estrogens are directly responsible for growth of leiomyomas, it is now apparent that progestins play an important, if not dominant role in the control of tumor mitogenesis. This information may be important when considering strategies for medical therapy directed at the myoma itself.

The most commonly encountered clinical manifestations of leiomyomas include heavy menstruation (menorrhagia), pelvic pressure, urinary frequency, and the perception of a pelvic mass on the part of the patient. While spontaneous abortion and infertility clearly seem to be related to leiomyomas in some cases, their general relationship to leiomyomas remains obscure. Pain is an uncommon sequella of leiomyomas. Indeed one of the factors that complicates the management of women found to have leiomyomas is that most are asymptomatic. And, while this may not be a problem in itself, asymptomatic leiomyomas may be falsely accused of causing symptoms of infertility, pain, or abnormal bleeding that are actually secondary to some other etiology. In such instances, unnecessary surgery, including hysterectomy, may be used to no avail. Conversely, small but clinically significant leiomyomas may reside within the uterus but beneath the endometrium, evading detection by physical examination. Finally, leiomyomas comprise the most common indication for hysterectomy in the United States, and therefore contribute significantly to morbidity and health care resource utilization.

Clearly, with respect to leiomyomas, gynecologists have at least two mandates. One is to appropriately evaluate women with and for leiomyomata, separating those that are clinically significant from those that are likely irrelevant, thereby allowing the patient the opportunity to make an informed choice regarding appropriate therapeutic options, including expectant management. Secondly, it is incumbent to seek interventions that provide the desired clinical outcomes with the least morbidity and utilization of resources.

**CLINICAL EVALUATION**

The usual clinical investigation is designed to determine if leiomyomas are responsible for the patients clinical problem, be it abnormal bleeding, infertility, recurrent abortion, or pelvic pressure or pain. This requires a carefully designed history, physical examination, and appropriate laboratory and imaging studies.

**History and Physical Findings**

The investigation usually starts with a detailed menstrual history, not only to evaluate for pregnancy and ovulatory status, but to determine the impact of the clinical problem on the woman’s life and life style. Ovulatory status is important, not only for the evaluation of women with infertility, but for those with abnormal bleeding as well. While leiomyomas can contribute to the volume of anovulatory bleeding, they are not a cause of anovulation per se. The ovulatory status is most cost effectively determined by the history. Women with cyclical, predictable menses every 21 to 35 days will be demonstrated to be ovulatory in at least 95 per cent of instances. Molimina may provide clues additionally suggestive of ovulation, and may include dysmenorrhea, mid-cycle
Munro Leiomyomas

unilateral pelvic pain, and premenstrual symptoms, such as breast tenderness, that are relieved by menses. Anovulatory bleeding patterns are typically irregular in timing and flow, and are often, but not always, interspersed with episodes of amenorrhea of varying duration. Indeed, the first anovulatory bleed may extremely heavy and can follow an extremely short or even non-existent period of amenorrhea. The history may provide clues to the cause of anovulation by searching for subjective features of the circumstances and clinical entities described above in the discussion of anovulation. The clinician should also screen for evidence of a congenital or acquired coagulopathy by reviewing the family history and the patient’s own medical history.

The physical examination is initiated with a general examination of the patient and should be directed in a way that allows comprehensive but efficient evaluation for the cause of the abnormal bleeding. A careful the speculum examination will generally reveal vaginal sources that include lacerations and tumors. The manual examination should be conducted in a logical progression focusing it on the clinical problem at hand. A careful bimanual examination of the corpus is performed seeking evidence of symmetrical enlargement that might be found with pregnancy, adenomyosis, or a centrally located intramural myoma. Asymmetrical enlargement suggests leiomyoma(s) but can be a finding encountered in nodular adenomyosis.

Laboratory Investigation

A hemoglobin and hematocrit should be considered the only routine laboratory assessments, with other ancillary investigations guided by the history and physical examination. If the diagnosis of ovulation is uncertain, luteal phase progesterone is appropriate. For women who are deemed anovulatory, a TSH will provide evaluation of thyroid function, and serum prolactin and/or serum testosterone may be ordered as indicated by the clinical picture.

The principle reason for sampling the endometrium is to evaluate the patient for the presence of endometrial hyperplasia or endometrial cancer, but the diagnosis of acute or chronic endometritis may also be made. There is evidence in postmenopausal women, not taking hormone replacement, that sonographically measured thickness of the endometrial echo complex (often called the endometrial stripe) is useful at defining a group of women at extremely low risk for endometrial neoplasia, thereby precluding the requirement to obtain an endometrial sample. However, to date, such data have not been validated in women in the reproductive years.

Structural Evaluation of the Oviducts and the Endometrial Cavity

For women who are planning to conserve the uterus, structural evaluation of the endometrial cavity is generally advisable. When infertility is an indication for myomectomy, tubal patency should be confirmed in case obstructed oviducts affect decisions regarding the nature and extent of the proposed surgery. Blind instrumentation of the endometrial cavity will occasionally suggest the presence of a structural abnormality such as a submucous leiomyoma. However, blind instrumentation has been demonstrated to be inadequate for accurate depiction of the structure of the endometrial cavity when hysteroscopy is used as the standard as polyps, leiomyomas and localized adenocarcinomas may be identified. Consequently, the definitive structural evaluation of the endometrial cavity requires imaging by radiological or ultrasonographic techniques and/or direct evaluation via hysteroscopy. Magnetic Resonance Imaging has recently been reported as a method for the assessment of the uterus, particularly for the presence of adenomyosis, or to distinguish adenomyosis from leiomyomas.
**Imaging**

*Radiological (Hysterography)*

The hysterogram is performed under fluoroscopic guidance using oil or water based radioopaque dye injected via a transcervical catheter into the endometrial cavity. Unfortunately, while there is value in performing hysterosalpingography for determining tubal patency, there is controversy regarding the value of this test for cavity evaluation. For example, in a retrospective study of 400 women who underwent both hysteroscopy and hysterogram, radiological imaging of was found equivalent to endoscopy. However, most studies suggest that hysterography is less accurate. For example, in a study using hysteroscopy and sonohysterography to evaluate women with abnormal cavity structure on hysterogram, 9 of the women were demonstrated to have a normal cavity. In another study of similar design and size (323 women) the incidence of false positive results with radiological 11.7% while the false negative results were found in 13.3%. Goldberg et al found that five of 26 women with filling defects on radiological hysterography were normal when examined by both sonohysterography and hysteroscopy. As a result, appropriately timed hysterosalpingography is probably the best approach for evaluating the tubes, and may have some value as a screening tool for the endometrial cavity. However, radiology should be liberally supplanted by other techniques when defining the location and extent of leiomyomas prior to surgery.

*Transvaginal Ultrasound*

Transvaginal ultrasound has been demonstrated extremely useful for the evaluation of the uterus for pregnancy and for structural abnormalities that may cause abnormal bleeding, including leiomyomas and polyps. While it is not consistently useful for evaluating congenital abnormalities such as defects in mullerian fusion or resorption, these anomalies are not known to cause abnormal uterine bleeding. Unlike many other imaging techniques, the assessment is a dynamic one, and the quality of the exam, and therefore its sensitivity and specificity, depend largely on the training, skill and experience of the sonographer.

Abnormal uterine bleeding is a common manifestation in pregnancy and may signal either an ectopic or non-viable intrauterine gestation. The use of ultrasound, in combination with assays of the β subunit of human chorionic gonadotropin in the management of women with bleeding in early pregnancy is well known and beyond the scope of this manuscript.

In the non-pregnant woman with abnormal bleeding, a thin endometrial stripe in combination with an absence of leiomyomas near the endometrial cavity is strongly associated with a negative hysteroscopic examination as demonstrated by Emmanuel and coworkers. In their study, transvaginal ultrasound was compared with hysteroscopic evaluation and successfully predicted a normal cavity in 135 of 139 women with abnormal uterine bleeding; 16 of 121 deemed to be abnormal by ultrasound, were found to be normal on hysteroscopy. These features make transvaginal sonography a suitable screening test for evaluation of the endometrial cavity in women with abnormal uterine bleeding where a normal examination can generally be relied upon. However, in the presence of a thick endometrial stripe or myomas suspiciously close to the endometrial canal, additional evaluation with sonohysterography or hysteroscopy (see below) will be
Munro Leiomyomas

necessary to complete the evaluation. The thick endometrial stripe may reflect
unopposed estrogen effect, including hyperplasia or adenocarcinoma, or may be a
reflection of an endometrial polyp, similar in consistency to the endometrium itself.

**Sonohysterography**

The limitations of simple sonography of the uterus can be largely overcome by
performing the scan following the instillation of saline (or other suitable fluid) into the
endometrial cavity. Sonohysterography (SHG) is perhaps the most commonly used term
for the techniques, but there exist a number of synonyms in widespread use including
hysterosonography and saline infusion sonography (SIS) (most have ceased use of the
term ‘hysterosonogram" because of the potential for confusion with
‘hysterosalpingogram'). The technique was first introduced by Nannini *et al* in 1981
using transabdominal scanning following the transcervical introduction of fluid contrast\[xi].
However, in this form the approach was not widely utilized, at least in North America,
until the introduction of the transvaginal approach in the early 90s\[xii]. When compared to
office hysteroscopy, SHG seems, in most studies, to have at least equal sensitivity for the
detection of intrauterine pathology including polyps, myomas, and synechiae and there is
less pain perceived by the patient\[xiii, xiv]. In some instances, it is less specific at
distinguishing between polyps and myomas when compared to hysteroscopy, but
ultrasonic evaluation is more accurate at determining the size and myometrial extent of
leiomyomas\[xv]. A limitation to sonohysterography is that it does not allow for the
simultaneous removal of selected visualized lesions such as polyps and small myomas, a
disadvantage when compared to diagnostic hysteroscopy.

Patient preparations for the performance of a SHG are minimal. For women with
valvular heart disease, or a history suggestive of previous pelvic infection appropriate
prophylactic antibiotics are required. Administration of non-steroidal
antinflammatory agents such as ibuprofen or sodium naproxen is optional as a means
to diminish procedural discomfort. Because a full bladder is not necessary, the patient
should void prior to the procedure to reduce posterior deflection of the uterus. A
conventional transvaginal ultrasound is performed with the patient in a modified dorsal
position during which the uterus and adnexal structures are evaluated. Then, an open-
sided speculum is positioned in the vagina to expose the cervix that is cleansed with an
appropriate antiseptic solution. Following this long (usually about 25-cm) intrauterine
insensation catheter is flushed with saline or other sterile liquid (eg. saline, glycine,
Ringer’s lactate) and then positioned in the endometrial cavity. Prior to insertion, the
catheter is primed to prevent the introduction of bubbles that would obscure sonographic
assessment. Cervical dilation is rarely required. In circumstances where the cervical
canal is lacerated or patulous a balloon-tipped catheter may be necessary to contain the
fluid in the endometrial cavity\[xvi]. After the catheter is successfully introduced, the
endometrial cavity is slowly distended with fluid (usually 5-30 cc) using an attached 60-
cc syringe and the uterus is systematically examined in real time.

Sonohysterography is extremely useful for determining the presence or absence of
polyps or intracavitary leiomyomas that may contribute to abnormal uterine bleeding and
can provide information about the myometrium and its involvement with myomas not
possible with hysteroscopic imaging. The major deficiency, compared to hysteroscopy, is
the inability to concurrently remove selected lesions at the same setting.
Munro Leiomyomas

Endoscopy

Diagnostic laparoscopy has limited utility in the evaluation of the uterus in women with abnormal uterine bleeding, for it is difficult to determine which, if any identified myomas contribute the genesis of the clinical problem. Diagnostic hysteroscopy, on the other hand, is an office or clinic-based procedure that allows for the detection of intracavitary myomas, polyps, and other lesions that may be the cause of the bleeding. Furthermore, at the time of hysteroscopy, targeted tissue samples may be obtained from the endometrium itself, and, in some instances, the responsible lesion, such as a polyp or small myoma, may be removed in the same setting. Pantaleoni first described Hysteroscopy in the 19th century for the evaluation of a postmenopausal woman who was suffering from abnormal uterine bleeding. Indeed, the author described utilizing chemical cauterization to eradicate the identified endometrial polyp.

Diagnostic hysteroscopy has received relatively lukewarm response from North American clinicians for a number of reasons that may include a number of factors including the capital cost of equipment, poor anesthetic technique, and a lack of familiarity with the technique educational institutions.

The ability of diagnostic hysteroscopy to provide information not predictably obtainable by blind endometrial sampling has been adequately documented. In the reproductive years, hysteroscopic diagnosis of intrauterine lesions is particularly useful particularly in women with ovulatory uterine bleeding. Fraser reported that leiomyomas were found in 20% of 182 such women, and only 60% had a normal endometrial cavity. However, curettage can provide information (eg endometritis, hyperplasia) not otherwise obtainable from hysteroscopic evaluation alone, or even that associated with directed biopsy. Consequently, the principal advantage of diagnostic hysteroscopy over blind sampling is that structural anomalies are more likely detected and defined. While hysteroscopy is superior to blind instrumentation for determining structural defects, it is comparable to SHG described above, for the identification of myomas and polyps.

Myometrial Evaluation

The myometrium is assessed to determine the extent of submucous myoma involvement and to identify adenomyosis or to distinguish between leiomyomas and adenomyomas. Detection of adenomyosis remains an imprecise process and the clinical significance of adenomyosis itself is controversial.

Transvaginal Sonography

Ultrasound has been demonstrated useful for the evaluation of myomas in the myometrium, although variations in echogenicity can, in some instances, reduce the sensitivity of the examination.

Transvaginal ultrasound has been reported as being useful in the diagnosis of diffuse adenomyosis. In 1992, Fedele et al described a sensitivity of 81% and specificity of 74% in detecting adenomyosis in a cohort of women who subsequently underwent hysterectomy for ovulatory menorrhagia and an enlarged uterus. Vercelini et al reported a specificity of 83% while the sensitivity was 67% (Reference same as Vercelini in Histology) while Brosens et al described essentially opposite results (sensitivity 80%; specificity 50%). Perhaps because of these inconsistent results and uncertainty regarding the clinical significance of adenomyosis, the utility of ultrasound in the clinical diagnosis of adenomyosis has to date, been limited.
Magnetic Resonance Imaging

The use of magnetic resonance imaging (MRI) in the evaluation of the
myometrium for leiomyomas and adenomyosis was first described in the middle
1980s. A group from Kyoto University in Japan correctly predicted the histopathologic
(hysterectomy) findings in 92 of 93 cases including 71 with leiomyomatata, 15 with
adenomyosis, and six with a combination of the two. The one case missed had a
diagnosis of adenomyosis after the MRI predicted leiomyomas. These data suggest that,
at present, MRI is more accurate at distinguishing leiomyomas from adenomyosis than is
transvaginal sonography. However, management algorithms, integrating the two imaging
modalities have not yet been developed. Nevertheless, because leiomyomas, unlike
adenomyosis are amenable to myomectomy, MRI seems valuable when one or a
combination of clinical symptoms and transvaginal ultrasound suggests the possibility
that adenomyosis exists. In such circumstances, a number of women would be spared the
time, cost, and trauma associated with a laparoscopy or laparotomy-based myomectomy.

Myometrial Biopsy

Myometrial biopsy is a relatively new, and little used modality that has undergone
investigation as a method for the diagnosis of adenomyosis. One method for obtaining
such myometrial samples is the use of a transcervical needle biopsy, reported by
Verecellini to have high specificity (96%) but poor sensitivity (45%) when compared to
histopathological examination of hysterectomy specimens. Similar results were reported
by Popp et al, with a per specimen specificity of 100% but a sensitivity of only 8 to 18%
using either laparoscopically- or ultrasonographically-directed technique. While these
techniques, seem, at least for the moment to have limited clinical applicability,
hysteroscopic endomyometrial biopsy may have a place in the identification of patients
less likely to undergo successful endometrial ablation or resection. McCausland has
described a technique whereby an endomyometrial strip is taken from the posterior wall
of the endometrial cavity using a resectoscope and a loop electrode. Women who have
“deep” endometriosis (>1mm) have been demonstrated by him to have a significantly
increased chance of failure with respect to both dysmenorrhea and menorrhagia.

Investigative Strategy

A successful investigative strategy requires conscientious, judicious, and
appropriate use of the tactics and techniques described above. First a careful history,
physical examination, and appropriate laboratory investigations are performed to evaluate
for hemodynamic instability, pregnancy, ovulatory status, and extrauterine causes of the
bleeding. The subsequent steps depend, not only on the ovulatory status, but also on the
resources readily available to the clinician, and the wishes of the patient after she has
undergone appropriate counseling following the initial assessment. Consequently, the
order of the following tactical steps may vary.

For women determined to have ovulatory abnormal uterine bleeding, an
experienced sonographer (Figure 4) performs a transvaginal ultrasound. If the ultrasound
demonstrates a normal endometrial echo complex without involvement of the cavity with
a submucosal myoma, the diagnosis of ovulatory dysfunctional uterine bleeding is still
likely and a trial of medical therapy is justified. If the sonogram suggests that the
endometrial echo complex is abnormally thick, or if there is suspected involvement by a
Munro Leiomyomas

submucous myoma, either an office hysteroscopy or a sonohysterogram are performed. If the resources and expertise are readily available, these procedures may be performed during the same, initial visit. If a causative polyp or myoma is identified, the patient is counseled regarding appropriate surgical management. For women in whom hysteroscopy has identified a submucous myoma with uncertain myometrial extension, sonohysterography may be an appropriate test to determine the most appropriate surgical route or technique.

MEDICAL MANAGEMENT

Medical management of symptoms associated with leiomyomas has been somewhat controversial for a number of reasons. One is the perception that simple or traditional medical therapy has little if any chance of success. The one perceived exception, GnRH agonist therapy, is seen as expensive, cumbersome and requiring long term regimens that are associated with potentially clinically significant sequellae. These features, in combination with reimbursement systems that disproportionately reward surgical interventions, have collectively resulted in a relative paucity of clinical experience with medical intervention for symptomatic leiomyomata.

Iron and DUB Regimens

Iron replacement is essential for anemic women, and, in instances of heavy but limited bleeding, may be all that is necessary to ameliorate the principle symptom, fatigue. Medical therapies such as NSAIDs, antifibrinolytics, danazol, and progestins or combination oral contraceptives may successfully treat bleeding associated with leiomyomas, especially if the tumors are not the cause of the bleeding symptoms. When successful, it may be because the patient’s leiomyomas are minimally symptomatic or asymptomatic and she actually has dysfunctional uterine bleeding.

GnRH Agonists

GnRH agonists, because of their ability to create a temporary hypogonadotropic state, can induce temporary and reversible shrinkage of both total uterine volume and the volume of the myomas themselves. The reduction in total uterine volume generally ranges from 40% to 60%, with leiomyoma shrinkage even more variable (0-100%). The mechanism of response to agonist therapy is not clearly understood, but is apparently multifactorial. Leiomyoma blood flow, as measured by doppler studies of resistance and pulsatility index is reduced by 25-40% and histopathological examination has demonstrated a decrease in arterial diameter by 27%. The proportion of collagen in the lesions and other factors such as density of estrogen receptors, vascularity, cell proliferation rates, and degree of inflammatory cell infiltration affect the response to GnRH agonist therapy. Most studies have demonstrated that myoma and uterine volume expand to pretreatment levels within months of the cessation of therapy.

GnRH agonists have a role at least in selected patients for management of abnormal uterine bleeding related to myomas. These management strategies may be considered to be short, interemediate, or long term.

Short Term

Short term use (2-3 months) of GnRH agonists for the medical management of leiomyomatas is a strategy that may be attractive for a number of reasons. First, GnRH agonists, by virtue of their ability to create amenorrhea, provide an opportunity for the
Munro Leiomyomas

anemic woman to reconstitute her iron stores and hematocrit without resorting either to blood transfusion or emergency surgery\textsuperscript{xxxix}. Second, the temporary hypogonadal state created by GnRH agonist administration results in reduction in both vascularity and size of the uterus and myomas themselves. These manifestations may facilitate the surgical procedure performed and result in a reduction in selected complications. For example, using the knowledge that maximal reduction in uterine and myoma volume is achieved by three months of GnRH therapy\textsuperscript{xli} Stovall and associates evaluated women with large myomatous uteri (>14 week size) scheduled for hysterectomy. They demonstrated that 80% of the women were able to undergo vaginal hysterectomy if GnRH agonist therapy was utilized for the three months immediately prior to surgery\textsuperscript{xlii}. And there is evidence that preoperative GnRH agonists may reduce the duration and risks of hysteroscopic myoma resection, particularly intravasation of distension media\textsuperscript{xliii}. Finally, medically induced amenorrhea is a way for the woman to defer surgery, either to a more appropriate time. For example, a teacher who might otherwise require surgery in April, could use GnRH analogs to avert loss of teaching time until July, when school was out

Intermediate Term

GnRH agonists may be used in courses of intermediate duration (4-6 month) for women with leiomyomata, without concern about significant losses in bone density. However, any women will suffer from the vasomotor symptoms that usually accompany the use of GnRH agonists beyond one to two months and will benefit from the use of “add-back” therapy with a gonadal steroid based regimen. The woman most likely to use an intermediate term course is an individual who wishes to defer planned surgery beyond three months. However, there are other situations including the woman in her late 40s or early 50s who may wish to try to avoid surgery altogether by using single or repeated intermediate term courses of agonist. Indeed there is evidence that such an approach may have lasting benefit. Scialli and Jestila performed a study on women who had abnormal uterine bleeding related to leiomyomas and who underwent six months of leuprolide acetate (LA) therapy\textsuperscript{xliii}. They randomized women to receive either placebo or medroxyprogesterone acetate following discontinuation of the LA. Surprisingly, a majority (about 55%) of each group experienced an improvement in their bleeding for months following discontinuation of agonist. This evidence suggests that GnRAl agonist therapy may have unexpected prolonged therapeutic benefit in women with myoma-associated uterine bleeding, making the use of intermittent courses a potential non-surgical strategy for women in the late reproductive years.

Long Term

There is relatively little published experience with long-term (> 6 months) GnRH agonist therapy for leiomyomas. Furthermore, long term use of GnRH agonists have been shown to result in progressive osteopenia, and, potentially could have other sequellae including those involving the cardiovascular system. There has been some concern regarding the most appropriate add-back regimen for estrogen has the potential for exacerbating the bleeding process, while progestins may impede the volume reduction effect of the agonist. However, a comparative study by Friedman et al has demonstrated that a continuous estrogen progestin regimen provides adequate control of vasomotor symptoms, insignificant uterine bleeding, and stable uterine volume, bone density, and serum lipid fractions\textsuperscript{xlv}. Progestin-only regimens were associated with increasing uterine volume, apparently confirming the influence of progestins on myoma growth.
Antiprogestational Agents

The antiprogestin RU-486 or mifepristone has been available in limited fashion for a number of years. Murphy and coworkers demonstrated in 1993 that RU 486 was capable of reducing the volume of leiomyomas by about 50%, without the concomitant effects on circulating gonadotropins and gonadal steroids, including both estrogen and progesterone witnessed with GnRH agonist therapy.

SURGICAL MANAGEMENT

Hysterectomy has been the standard of care for much of the 20th century, for women with symptomatic leiomyomas being responsible for more than 30% of the half million hysterectomies performed each year in the United States. Certainly, hysterectomy still has a major role to play in the management of women afflicted with symptomatic leiomyomata. Indeed, for women who have completed childbearing, vaginal hysterectomy is likely associated with less operative morbidity and cosmetic insult than, for example, laparotomic myomectomy. And many women with enlarged uteri can avoid an abdominal approach to hysterectomy with the preoperative use of GnRH agonists, as discussed later in this section. In addition, supracervical hysterectomy is an approach that may reduce operative morbidity and which may be particularly suitable for women with symptomatic leiomyomas.

However, many women wish to retain their uterus, usually for reproductive purposes, making hysterectomy an unacceptable solution. And even women who chose not to become pregnant in the future, are interested in surgical options that are less invasive, less costly, and associated with a more rapid return to work and other activities. For these women, alternatives to hysterectomy are an imperative.

Myomectomy was the initial and remains the most common uterus sparing approach to the surgical management of leiomyomas. Atlee first reported abdominal myomectomy in 1845. Despite, and perhaps because of its early introduction into gynecologic practice, abdominal myomectomy has not been subjected to rigorous clinical evaluation comparing it with expectant, medical and other surgical approaches to the various manifestations of uterine leiomyomata. Consequently there remains controversy regarding its value, particularly for the treatment of infertility.

The advent of operative endoscopy added new surgical options for the woman with symptomatic leiomyomas. A number of potential candidates for the abdominal approach were removed with the introduction of hysteroscopically directed management of submucosal myomas by Neuwirth in 1978. Although Semm first described laparoscopic myomectomy, Dubuisson et al published the first series of laparoscopically directed myomectomies as a potentially less morbid alternative to a laparotomy-based approach.

Indications for myomectomy by any approach are currently being re-evaluated, as cost containment incentives, medical therapy, consumer pressure, and academic introspection combine to reinforce the long known fact that most myomas are asymptomatic and do not require treatment. The incidence of leiomyosarcoma is so rare, even in rapidly growing leiomyomata, that, in the vast majority of instances malignancy is not a relevant consideration. Even in the face of symptoms, it is prudent not to assume that the patient complaints are caused by the myoma felt on examination or imaged on ultrasound.

As a result, the practicing gynecologist is challenged to rethink her or his approach to the woman with myomas. And even when surgery is indicated, there are a number of potentially new approaches not available in formal residency training programs, even in recent years. This review should serve as a guide to selection and management of women...
Munro Leiomyomas
who require abdominal myomectomy by either the laparoscopic or abdominal approach.

**Patient Selection**
The principle advantage of abdominal myomectomy is conservation of fertility by
the avoidance of hysterectomy. When fertility is not an issue, the patient must carefully
weigh the potential disadvantages of the procedure when compared with expectant and
medical therapy, and with hysterectomy itself.

**Abnormal Uterine Bleeding**
The most common symptom ascribed to leiomyomata is abnormal uterine bleeding,
most often menorrhagia. However, it is quite possible that this relationship is overestimated
when asymptomatic myomas are found in association with other focal lesions (eg
endometrial polyps) or in the face of dysfunctional uterine bleeding.

The etiology of abnormal uterine bleeding associated with leiomyomas is unknown,
but presumed to be related to diminished control of endometrial bleeding at the time of
menstruation, likely secondary to alterations in the endometrial vasculature. It is perceived,
but not proven, that most leiomyomas that cause bleeding do so while distorting the normal
contour of the endometrial cavity. Consequently, the clinician should seek to evaluate the
endometrial cavity for leiomyomas or other focal lesions using sonohysterography or
hysteroscopy, and/or attempt medical therapy with antiprostaglandins or oral contraceptives
before concluding that abdominal myomectomy is an appropriate therapeutic option for
abnormal uterine bleeding.

**Impairment of Reproduction**
Myomas have been associated with a variety of reproductive disorders that include
infertility, recurrent spontaneous abortion and preterm labor. For this spectrum of clinical
entities, there exist a variety of causes, some obvious and many others unknown or
undetectable. It is in the absence of other discernable factors that myomas are often
impugned as the cause of the problem, especially infertility. However, there exist no
comparative studies adequately designed to demonstrate that leiomyomas are associated
with adverse clinical outcomes. Furthermore, the reported success rate following
abdominal myomectomy for either infertility or recurrent pregnancy loss is about 45%
similar to that observed when expectant management is chosen. Intuitively obvious
exceptions include significant submucous lesions and myomas that obstruct the tubal lumen
in the cornu. Consequently, the coexistence of an otherwise asymptomatic leiomyoma may
be, but is probably not the cause of the reproductive failure. It is clear that if myomectomy
is to be considered that all other detectable causes of infertility be excluded, especially tubal
obstruction, anovulation and the male factor. At the time of hysterosalpingogram, the
combination of patent tubes and a distorted endometrial cavity may point to those patients
who may benefit from myomectomy.

**Pelvic Pain**
Uterine leiomyomata are frequently associated but rarely the direct cause of pelvic
pain, excepting the relatively uncommon instances of red degeneration and torsion of a
pedunculated subserous lesion. Submucous lesions theoretically contribute indirectly to
dysmenorrhea, likely secondary to outlet obstruction or induced menorrhagia.

Pain associated with red degeneration is usually appropriately managed expectantly,
providing symptomatic relief with analgesics. Most submucous lesions are best treated via
Munro Leiomyomas

hysteroscopic means. On the other hand, symptomatic, pedunculated subserous myomas are ideally managed by laparoscopically-directed technique.

Pressure and Urinary Tract Symptoms

Infrequently, the location and size of leiomyomas may be adequate to cause pressure symptoms, including urinary frequency and urgency. However, urinary incontinence is even less common and is virtually invariably caused by other factors. Posterior myomas may contribute to tenesmus if they are of sufficient size.

The patient should be cognizant that such symptoms may not be related to the presence of the myoma, unless it is of extremely large proportions, and that urinary incontinence will generally require other medical or surgical therapy. As a result, myomectomy for such symptoms should be performed only in very limited circumstances.

Pregnancy

Myomectomy in pregnancy is to be avoided. The only potential exception is the severely symptomatic pedunculated subserous fibroid. In other circumstances, any surgical intervention is likely to result in severe hemorrhage.

Risk of Leiomyosarcoma

The threat of malignancy is frequently the reason that myomectomy is performed on asymptomatic or minimally symptomatic lesions. However, leiomyosarcoma is extremely rare, particularly in premenopausal women, and, contrary to some perceptions, is a de novo neoplasm, not a result of malignant transformation of a benign tumor. The malignant tumor is more frequently encountered in the fifth or sixth decade of life. While even premenopausal rapid enlargement is rarely associated with malignancy, postmenopausal enlargement may be more ominous.

Understanding that a myoma is almost certainly benign should give confidence to both the patient and her physician that expectant or medical approaches, if effective, are appropriate. Furthermore, the use of preoperative GnRH analogues in selected women who require surgery can be justified. Rapid growth of apparent myomas in post menopausal women is likely a contraindication to conservative surgical procedures like myomectomy.

Preoperative Preparation and Evaluation

Counseling and Evaluation

Preparation for myomectomy is undertaken in view of the need of the patient to understand the procedure, considering the expectant, medical, and other surgical options. The patient should have a clear understanding of potential complications as well as the expected and the possible degree of post-operative disability. The potential for unanticipated hysterectomy should be reviewed. All of this information should be documented in the clinical notes and the informed consent document.

Most would find it prudent to preoperatively confirm tubal patency and to obtain as much information as possible regarding the location and extent of the myomas using one or a combination of hysterosalpingogram, sonohysterography, and hysteroscopy. Such information may help in the selection of incision sites, and, perhaps, in determining the route of access. If there is clinical suspicion that the masses in the uterus represent adenomyosis,
Munro

MRI scanning may be appropriate, for, in such instances, conservative surgery is unlikely to improve reproductive performance. Ancillary investigations should be performed as appropriate, however, a hemoglobin/hematocrit is essential. In addition, because of the potential for blood loss, the patient should be provided the opportunity for collection and storage of autologous blood, provided her hemoglobin levels and the time available before surgery permit.

GnRH Analogues

Preoperative administration of GnRH analogues may provide value, in at least selected instances. For the woman with anemia, creation of amenorrhea can be expected to facilitate the restoration of hemoglobin levels, provided sufficient amounts of iron are administered over an adequate amount of time.\textsuperscript{lvii,lviii} In such instances, autologous blood may more safely be obtained. Consequently, the duration of administration of the analogue is related to the pre-existing degree of anemia and the response of the patient to iron or other appropriate therapy.

There exists controversy regarding the routine use of GnRH analogues for the woman without associated anemia. Proponents have suggested that agonists reduce operating time, intraoperative blood loss, and the need for transfusion, and as well increase subsequent fertility rates. Those opposed to routine administration have suggested that these advantages do not exist and that myomectomy may be further complicated by difficulties in intraoperative discrimination of myoma from myometrium. Unfortunately, many of the reports supporting the use of GnRH analogues in these instances are observational series without appropriately selected comparison groups.\textsuperscript{lix,lx} A randomized clinical trial (RCT) by Kiltz \textit{et al.} confirmed that myoma size was reduced in agonist treated patients compared with controls. However there was no difference in the amount of measured blood loss.\textsuperscript{lxix} Friedman \textit{et al.} published a placebo-controlled RCT that concluded that pre-operative GnRH agonist reduced intraoperative blood loss (213 vs 300 cc) in all their cases, but especially when the uterus was very large (189 vs 390 cc).\textsuperscript{lxii} Golan \textit{et al.}, in another RCT, demonstrated reduced operating time (49 minutes vs 70 minutes) and less blood loss (320 vs 476 cc) in the agonist pre-treated group. However, the impact of this difference in blood loss is questionable given the fact that there was no difference in the transfusion rates. There is also controversy regarding the impact of GnRH analogue use on the ability of the surgeon to detect small myomas intraoperatively and on the subsequent risk of recurrence. In an RCT, Fedele \textit{et al.} detected more post myomectomy myomas in women pre-treated with agonist than when no such therapy was used.\textsuperscript{lxiii} It should be noted that these myomas were detected on ultrasound and their clinical significance could not be assessed. Furthermore, a contrary opinion was provided by Friedman \textit{et al.} who used an RCT to show that myoma recurrence was more frequent when four or more tumors were resected and recurrence was not associated with preoperative medical therapy.\textsuperscript{lxiv}

In summary, GnRH analogues are clearly useful in allowing otherwise anemic women to enter surgery with normal hemoglobin and stored autologous blood. Their value in changing the clinical outcomes associated with myomectomy is less clear. There seems little doubt that the size of intramural lesions may reduce following the use of pre-operative agonist therapy, and that the maximum effect is usually realized in two months. If, in the judgement of the surgeon such a change would facilitate the procedure then selective use can be justified. Clearly, larger multicenter trials will be necessary to more adequately assess the impact of pre-operative GnRH analogues on clinically relevant parameters such as operative time, transfusion rates and subsequent fertility.
Munro Leiomyomas

Procedures

The principles of contemporary myomectomy were established by Bonney with his publication of 20 years of experience, and amplified by his 1946 report of 806 cases. The low morbidity and mortality were rather remarkable with only two deaths in the last 400 cases (overall mortality of 1.1%). The limitations (and advantages) of laparoscopy have given rise to reconsideration of these classical approaches. In addition, the advent of GnRH agonists and adhesion prevention techniques has given rise to new controversies in the technique of myomectomy.

Laparotomic Myomectomy

Following entry into the uterine cavity, care is exercised in manipulating tissue and in the use of sponges and packs, thereby reducing the incidence of adhesions. There exist a number of approaches that may reduce blood loss, including preoperative GnRH agonists, mechanical vascular tourniquets, myometrial injection of vasoactive substances, and careful dissection technique. Vascular tourniquets are applied after creating windows in the broad ligaments that allow straps (usually urethral catheters or penrose drains) to be placed around the uterine isthmus occluding the blood supply from the uterine arteries. The vessels in the infundibulopelvic ligaments can be occluded bilaterally with vascular clamps, thereby obstructing the blood supply from the ovarian arteries. The vasoactive substance of choice is dilute vasopressin, 20 units in 20-100 cc injected around the myomas in a fashion that minimizes potentially dangerous intravascular infusion.

Uterine incisions are fashioned in a way that minimizes the chance of fertility-threatening adhesions. A midline incision is created, preferably on the anterior wall of the uterine fundus and as many myomas as possible are removed through this portal. Identification of the appropriate dissection plane is facilitated by incising into the myoma. Then the myoma is grasped with a tenaculum or towel forceps and dissection is performed with a combination of sharp and blunt technique, taking care to identify and secure the blood supply to the tumor. Should posterior myomas exist, an attempt is made to remove them via an anterior fundal hood incision extended posteriorly to provide access to the posterior myometrium. Such an incision should reduce the incidence of posterior adhesions involving bowel, fallopian tubes and ovaries. The uterus is palpated to detect the presence of any other myomas before the myometrial wall is repaired in layers with non reactive, absorbable suture, taking special care to accurately reapproximate the endometrium.

There has been much debate regarding the ideal dissection technique. Although most have used dissection with scissors, some have advocated the use of lasers or ultrasound ("Harmonic Scalpel") claiming reduced adhesions and improved reproductive outcome. However, while it is possible that there may be less blood loss associated with energy based modalities, the literature contains no evidence that relevant clinical outcome is improved.

Reduction in the incidence of post myomectomy adhesions is desirable as such a result is thought to improve pregnancy rates. Avoidance of posterior incisions has already been stressed and it is prudent to apply microsurgical techniques including meticulous hemostasis, careful tissue handling and the use of fine caliber suture on peritoneal surfaces. There is some information supporting the use of adhesion barriers over myomectomy incisions. Unfortunately, no data exists comparing the impact of adhesion-reducing technique on the most important clinical outcome, pregnancy.

Laparoscopic Myomectomy
Munro Leiomyomas

Laparoscopically directed myomectomy is a feasible procedure as demonstrated by a number of observational studies. However, the spectrum of myoma size and location, the difficulty with morcellation and removal, and the technical requirements for manipulation of needles and suture make the procedure difficult to perform. Such difficulties also complicate clinical outcome based evaluation. Consequently, at this time, there exist no comparative studies evaluating relevant outcome variables such as fertility, cost of care or complications.

The principle potential advantage of laparoscopic myomectomy, compared to the laparotomy approach, is the reduction of both direct and indirect costs. The small incisions generally reduce the need for analgesia, allow earlier mobilization and alimentation, and facilitate earlier hospital discharge, frequently on the same day of surgery. In addition, the lack of a significant abdominal incision allows a faster return to economic productivity thereby reducing the indirect cost of care. Theoretically, the reduction in tissue handling and the need for packs and manual retraction reduce tissue trauma and subsequent adhesions.

On the other hand, multiple myomas cannot usually be removed through the same incision and the surgeon loses the ability to palpate uterine tissue, detecting smaller myomas. It is also more difficult to apply laparoscopic technique to myomas in problem areas such as adjacent to the uterine arteries or the cornu thereby preserving tubal patency. As is the case with any laparoscopic procedure, there are geometrical limitations posed by the location of the instrument ports. In some instances at least, it may be more difficult to reapproximate myometrial and serosal tissue, a feature that may enhance the development of adhesions. Morcellation of the tissue is difficult; the larger the myomas, the greater the need for morcellation. All of these factors conspire to increase operating time, frequently offsetting the reduction in post operative direct costs intrinsically associated with laparoscopic surgery. However, anectdotally at least, very experienced and skilled surgeons seem to be developing skills that allow a greater number of myomectomies to be performed via the laparoscopic route.

Instrumentation

As with any laparoscopic uterine procedure, an appropriate uterine manipulator is critically important to successful completion of the case. The manipulator should afford transitions between extreme anteversion and retroversion, preferably via an articulating hinge located near the insertion through the cervix. There is value in either internal or external fixation of the device to the uterus thereby allowing rotational exposure of the lateral aspects of the corpus and cervix. Examples of acceptable devices include the Valtchev, Pelosi (Apple Medical), Rumi (CooperSurgical) and Clearview (Ethicon Endosurgery) uterine manipulators. Also of value is the ability to inject dye into the endometrial cavity facilitating its location and allowing the demonstration of tubal patency.

It is important to have available appropriate hand instruments. Grasping instruments can include tenaculums, myoma screws or large caliber multitoothed forceps necessary to grasp the tumors while they are being incised or morcellated. Smaller caliber five millimeter toothed grasping forceps are exceedingly useful for grasping the edge of the uterine incision to apply countertraction. A pair of laparoscopic needle drivers are necessary for closure of the defects created by myomectomy. There are available a variety of such devices to fit the varying preferences of the surgeon. Needles for injection of vasoactive substances are available commercially but spinal needles (22 gage) are effectively passed through the anterior abdominal wall.
Munro Leiomyomas

There is a degree of controversy regarding the appropriate tools for dissection and the creation of incision. While some use either a KTP or Nd:YAG laser, we prefer to fashion the incisions with a monopolar electrosurgical needle electrode, although bipolar devices are also available. Subsequent dissection is performed mechanically with scissors; hemostasis is provided by appropriate bipolar or unipolar forceps. Many find that the ultrasonically vibrated “Harmonic Scalpel” is well suited to the creation of serosal incisions and for the dissection of the tumor from the underlying endometrium.

Morcellation is perhaps the most tedious aspect of laparoscopic myomectomy and is responsible for much of the additional time spent performing endoscopically directed removal of leiomyomas. The time spent morcellating myomas is directly proportional to the size of the tumor and inversely related to the length of the incision used to remove the fragments from the peritoneal cavity. Morcellation methods include the use of scissors, ultrasound, and electricity as well as manually or electrically activated cylindrical cutting tools. Scissors are more effective if they are large in caliber (10 millimeter shaft) with long sturdy blades. The ultrasonic/ mechanical energy from a Harmonic Scalpel (Ultracision Inc) can be used, but current forms of the device are generally slower than many would like. If unipolar energy is employed, the myomas must remain attached to the uterus to allow the completion of the circuit. Bipolar cutting electrodes (Erbe Medical; Everest Medical) hold promise and can be used even when the myoma free in the peritoneal cavity. The Semm morcellator (Wisap) is a serrated cylindrical cutting tool that is manually twisted into a myoma held by a claw forceps. Recently, a similar technique has become automated with the use of an electrical morcellator (Karl Storz). Morcellation can also be facilitated using gasless laparoscopy with an instrument such as the “Laprolift” (Origin Medical Systems). With such a device, large scissors or scalpels can be used through the trocar incisions without the compromise of losing endoscopic exposure.

Pedunculated Subserous Myomas

Pedunculated myomas can be detached from the uterus following occlusion of the pedicle with suture or bipolar or unipolar electrosurgical coagulation. Some advocate the use of dilute vasopressin into the uterus at the attachment point of the pedicle prior to tissue transection. Scissors are used to divide the pedicle and the myoma is removed via an enlarged abdominal incision and/or following morcellation.

Subserosal and Intramural Myomas

The surgeon should carefully evaluate the enlarged uterus to determine the ideal incision sites considering the size and location of the myomas. Lesions that are near to the uterine arteries and those that impinge upon the intramural portion of the tube should be approached with caution or considered for laparotomy. Once the incision sites are selected, dilute vasopressin is injected subserosally and in the adjacent myometrium. We prefer to dilute 20 units of vasopressin in 100 cc’s of normal saline.

The serosa and pseudocapsule are incised with a laser, the “Harmonic Scalpel” or an electrosurgical blade or needle electrode. There is indirect evidence that horizontal incisions are associated with less bleeding because of the transverse orientation of the uterine vasculature. Detection of the optimal plane of dissection will be facilitated if the incision extends through the pseudocapsule into the whorled matrix of the myoma itself. Ideally, traction is applied to the myoma with a tenaculum or myoma screw, countertraction is placed on the incision edge with a toothed grasping forceps, and the dissection plane developed with scissors, laser or the Harmonic scalpel. When tissue bridges are encountered, the vessels within should be desiccated with electrical or ultrasonic energy.
Munro Leiomyomas

Generally there is a single, dominant vascular pedicle which should be managed in a similar manner. If, following removal of the myoma, there are bleeding vessels, electrosurgical desiccation or carefully applied fulguration are used to effect hemostasis. The side of the Harmonic scalpel, or the blunt hemostasis probe attachment are also usually effective for this type of bleeding.

Curved needle suturing with synthetic absorbable 2-O suture is necessary for closing the defect in the myometrium. The use of specially designed clips (LapraTy, Ethicon) can anchor and finish the running sutures used for myometrial defects, an approach that saves time even for experienced surgeons. The serosa can be closed with interrupted or continuous absorbable 3-O suture; we prefer a continuous “subcuticular” stitch. Such suturing requires excellent eye hand co-ordination in a two-dimensional medium; success requires a commitment to practice outside of the operating room.

The myomas are then morcellated using one of the techniques or devices described above, and are extracted through an expanded trocar incision or via a culdotomy, fashioned laparoscopically, usually over a sponge held in the posterior cul-de-sac by a ring forceps. Alternate devices are available that serve as a template for the culdotomy and which maintain the pneumoperitoneum with an inflated balloon. If a culdotomy is made it may be preferable to institute intraoperative antibiotic prophylaxis with a first generation cephalosporin such as cephalaxin. The intra-umbilical incision is the one most amenable to extension for the purposes of myoma extraction. Guidance for removal is provided by transferring the laparoscope to the suprapubic port. If a motorized morcellator is used, extraction can usually be accomplished through the midline suprapubic port.

Prior to completing the case some investigators utilize an adhesion “barrier” such as Gore surgical membrane or Tc-7 (Interceed, Johnson & Johnson Medical Products). If these adjuvants are used, it is important to acquire complete hemostasis prior to their application. Furthermore, it should be remembered that there are no currently available comparative data supporting the use of adhesion barriers following the performance of myomectomy.

Submucous Extension

Intramural myomas may extend into the endometrial cavity. Most laparoscopic surgeons may chose to select such patients for laparotomy. However, if the surgeon possesses adequate skill and experience, and capable assistants, the same principles of layered closure can be applied via laparoscopy.

Laparoscopically Assisted Minilaparotomy

Frequently, laparoscopically-directed technique is not feasible for a component of the case, such as dissection near the cornu of the oviduct. In such instances, the suprapubic incision can be enlarged sufficient to complete that portion of the dissection or other component of the procedure, often with externalization of the myoma and/or uterus. This type of hybrid procedure is facilitated by the use of an external lifting device such as the “Laprolift” (Origin Medical Systems). The injection of 0.5% bupivicaine into the incision at the end of the procedure alleviates the immediate post operative pain and may still allow early discharge, frequently on the day of surgery.

Investigative Surgical Approaches

A number of techniques have been developed or proposed as an alternative to myoma excision. The term “myolysis” has been coined to describe the use of laser or electrical energy to desiccate the tumors by laparoscopic or hysteroscopically directed
Munro Leiomyomas

means. The first such technique described was the use of a Nd:YAG laser set at 50 watts with the energy delivered by a 600 µ fiber in multiple concentric sites (1 puncture per 5 mm diameter sphere).\textsuperscript{lxxxi} The initial evaluation of 14 patients followed for 6 to 14 months showed no recurrence. However, Nisolle et al performed second look laparoscopy in 7 of their 20 Nd:YAG myolysis patients and found dense fibrous adhesions between the uterus and bowel or omentum in all seven.\textsuperscript{lxxxii} Other myolytic techniques that have been proposed or that are in the early phases of evaluation include bipolar electrosurgical desiccation and cryotherapy.

Another technique originally reported in the mid 1990s\textsuperscript{lxxxiii} is uterine artery occlusion, usually using embolization directed by interventional radiological techniques. Other reports have surfaced, lending at least some credibility to this technique as a means of treating symptomatic leiomyomata in women in whom fertility is not a concern\textsuperscript{lxxxiv,lxxxv}. The patient is treated in an angiographic facility under local anesthetic, with or without sedation. Pain seems to be a frequent enough side effect that most protocols include a day of admission for parenteral analgesia. While long-term data are lacking, women so treated seem to have prolonged periods of reduction in bleeding, and other associated symptoms, in association with measurable reductions in the size of their lesions.

These techniques are in a developmental phase; it is recommended that they \textit{not} be used outside the environment of an appropriately designed clinical trial. The concerns are obvious. Adhesions have been described, a circumstance that makes use in women who desire future pregnancy questionable. Furthermore, the ability of the myolysed uterus to tolerate the distension of a pregnancy without rupture has not been assessed.

Outcome Evaluation

Some aspects of the currently available data regarding myomectomy by laparotomy or laparoscopy have been briefly discussed in the text. Obviously absent from the literature are any well designed studies comparing the two approaches. Indeed there exist few comparative studies at all; most reports are of observational studies, and relatively few address the most clinically relevant outcomes.

Operative Morbidity

Morbidity at laparotomy for myomectomy was recently reviewed in 128 patients operated upon by 46 surgeons with varying amounts of training; a likely measure of procedure \textit{effectiveness} or the results in the hands of a spectrum of surgeons.\textsuperscript{lxxxvi} The average uterine size was consistent with 14 weeks gestation, and the average estimated blood loss was 342 cc. Five had blood loss in excess of one liter, the transfusion rate was 20\%, and one patient required intraoperative hysterectomy. Post operative complications included wound infection (1), deep venous thrombosis (1), and post-operative fever (15).

Laparoscopic myomectomy is a newer procedure, and, not surprisingly, available reports of operative morbidity are more reflective of the morbidity in the hands of experts, also known as \textit{efficacy}. Dubuisson et al reported 102 patients with few complications; two patients required conversion to laparotomy.\textsuperscript{lxxxvii} Nezhat et al described laparoscopic myomectomy on 136 patients with operating times ranging from 50 to 190 minutes for myomas ranging from 3 to 15 cm in diameter.\textsuperscript{lxxxviii} Blood loss ranged from 10 to 600 cc and two women required transfusion. Myomectomy was performed under laparoscopic guidance in 56 patients reported by Hasson.\textsuperscript{lxxxix} Surgery time ranged from 45 to 443 minutes, blood loss ranged from 10 to 400 cc (mean 75 cc) and no patients required transfusion. All procedures were completed laparoscopically and the
Munro Leiomyomas

average hospital stay was 1 day.

From these data it can be seen that laparoscopic myomectomy is feasible, even for relatively large lesions. However direct comparisons with myomectomy cannot be made due to the potential differences in patients, surgeons, pathology and indications.

**Adhesions**

Adhesions are, in themselves, generally not a concern. However, their presence is frequently used as a *surrogate outcome* variable when predicting the effect of a procedure on future fertility (despite little supporting evidence that this can be relied upon). Tulandi’s work demonstrating an increased risk of adhesions with posterior incisions has been described previously.\(^{xc}\) Hasson performed second look laparoscopy in a subset of his patients and found adhesions in 46%.\(^{xci}\) Nezhat *et al* performed second look assessments in 32 patients and found adhesions in 46 of the 56 operative sites. Adhesions seemed more frequent in posterior wall incisions and when suture was used to close the serosa.\(^{xcii}\) These results should be treated with caution and should not be generalized as there is almost certainly selection bias in the few patients undergoing reassessment laparoscopy.

**Reproductive Performance**

The impact of any series of myomectomies on infertility is difficult to assess as there are no available comparative trials. There should be concern given the fact that studies with long term followup fail to show post operative fertility that differs significantly from historical controls treated expectantly.\(^{xciii}\) Clearly, a number of studies have reported successful pregnancy following laparotomy-based\(^{xciv,xcv,xcvi}\) and laparoscopic myomectomy\(^{xcvii,xcviii,xcix,c}\) and it is likely that, in some instances, there is a cause and effect relationship. However, since the majority of myomas are probably unrelated to the cause of infertility, there seems to be little dramatic effect of myomectomy on pregnancy rates.

Some have argued that there may be greater risks of uterine wound dehiscence when pregnancy follows laparoscopic myomectomy, a concern magnified by a recent report of one such occurrence.\(^{ci}\) It is likely that if the surgeon adheres to the same closure principles when performing laparoscopic myomectomy that are used in the abdominal approach, the incidence of such a complication will remain low and similar to that associated with laparotomy.

Resection is the technique used to remove leiomyomata, with limitations provided by the size and location of the tumor. The uterus must be adequately distended to allow the electrosurgical loop to get around the myoma allowing resection. Myomata that have significant intramural content must be either partially removed, or excised under ultrasonic control to minimize the incidence of uterine perforation. There is a perception that the myometrium tends to contract and extrude these lesions into the endometrial cavity, thereby facilitating more complete removal. Furthermore, there is anecdotal evidence that at least some of these lesions more completely extrude themselves following the case, obviating the need for a second procedure, which may be performed at a later date if necessary.
References

4. Valle RF. Hysteroscopic evaluation of patients with abnormal uterine bleeding.
19. Goldrath MH, Sherman AI. Office hysterectomy and suction curettage: can we eliminate
42. Stovall et al A randomized trial evaluating leuprolide acetate before hysterectomy as a
44. Scialli AR, Jestila KJ Sustained benefits of leuprolide acetate with or without subsequent medroxyprogesterone acetate in the nonsurgical management of leiomyomata uteri. Fertil Steril 1995 Aug;64(2):313-20
47. Munro MG Supracervical hysterectomy: ... a time for reappraisal. Obstet Gynecol 1997 Jan;89(1):133-9
Munro Leiomyomas


Munro Leiomyomas


xlvii. Atlee WL. Case of successful extirpation of a fibrous tumor of the peritoneal surface of the uterus by the large peritoneal section. Am


Laparoscopic Retropubic Colposuspension Procedures
Andrew I. Brill, M.D.
Professor
Director, Gynecologic Endoscopy
Department of Obstetrics and Gynecology
University of Illinois at Chicago
Retropubic colposuspension is indicated after a surgically treatable form of urinary incontinence has been identified and the patient has failed or refused nonsurgical therapy. Since first reported by Vancaillie and Schuessler in 1991 (21), a number of publications have confirmed the ability to laparoscopically perform a retropubic urethropexy without added morbidity and with similar results in the short term. (22-28) Laparoscopic retropubic colposuspension simply accomplishes the traditional laparotomic procedure by a different means of surgical access. As with other advanced laparoscopic surgical procedures, technical requirements are more demanding than its laparotomic counterpart. Advanced laparoscopic skills are a necessity.

Advantages of the laparoscopic approach include elimination of the abdominal incision and unhindered visual access and exposure of the anatomic structures of the space of Retzius. The visual clarity and magnification of tissues permits more precise dissection, refined hemostasis due to identification of blood vessels prior to transection, less trauma to the per urethral tissues, more accurate placement of sutures, avoidance of injury to the urinary tract and neurovascular structures, and identification of associated herniations of the anterior endopelvic fascia. Postoperative complications including wound infection, retropubic hematoma, and detrusor instability may be reduced.

The laparoscopic approach has yet to be widely embraced secondary to the absence of prospective and long term comparative studies that utilize urodynamic assessments and the laparotomic approach as the gold standard, and to the technical demands of the procedure. Endoscopic suturing in the space of Retzius can be laborious and frustrating. The loss of depth of field and peripheral vision from monocular vision must be overcome. Suture placement is hampered by unstable needle holders, the tenacity of Cooper’s ligament, and restrictions in instrument mobility and angle of freedom. Extracorporeal knot tying has to be mastered. Overcoming these challenges requires practice, patience, and skilled assistance in the operating theater.

As more innovative surgeons continue to tackle the laparoscopic approach, modifications in technique will evolve in order to simply this procedure. A modification of the traditional suturing technique eliminates suturing into Cooper’s ligament by using staples to secure the lateral suture strand to this structure. (28) Sutting is completely eliminated by anchoring a piece of Prolene mesh between the pubocervical fascia and Cooper’s ligament with endoscopic staples. (24)

Regardless of which technique is used to accomplish the task, a complete preoperative needs assessment should antedate each surgical procedure. Does the patient have associated anatomic deficiencies such as a cystocele, enterocele, rectocele, or prolapse? Has she previously undergone abdominal or anti-incontinence surgery? Will the approach to the space of Retzius be transperitoneal or extraperitoneal? Will the method for colposuspension require the use of sutures, staples, or Prolene mesh? Will the method for retropubic dissection include mechanical, laser, electrosurgical or hydrostatic modalities for surgical anatomization?

PATIENT PREPARATION

A diligently completed informed consent should review the usual risks of retropubic surgery and include the risks of transperitoneal entry, the possibility of conversion to laparotomy, injury to the urinary tract, and postoperative voiding dysfunction. The patient should be trained to perform self-catheterization in case of postoperative bladder instability and supplied with straight catheters.
A single dose of an appropriate prophylactic antibiotic should be administered no more than one hour prior to surgery. After induction of general anesthesia or regional block, the legs are positioned to facilitate a retropubic urethropexy with the aid of vaginal manipulation. This is accomplished by adjusting the patient's torso and extremities to a low dorsal lithotomy position with the legs and feet supported by Allen Universal Stirrups (Allen Medical, Mayfield, Oh.), or by keeping the legs in a flat position and flexing the knees and abducting the thighs to oppose the plantar surfaces of the feet in a “frogleg” position.

After appropriate antisipetic preparation of the vagina and operative field, the patient is draped with a combined laparotomy and lithotomy drape for access to both the abdomen and perineum during surgery. A three-way 24 French foley catheter is placed in the bladder and the bulb inflated to 20cc in order to help identify the urethrovesical junction during surgery.

TROCAR CONSIDERATIONS

The umbilical trocar site is used for a conventional or operating laparoscope and mechanical balloon dissectors. Accessory trocar sheath diameters are dictated by the endoscopic instrumentation specific to each method for colposuspension. All ports can be used for the interchange of ancillary instruments as such the suction irrigator, grasping forceps, needle holder, curved monopolar scissors, bipolar forceps, and Kittner sponge dissector. A 10mm trocar is needed for the unhindered passage of typically used suture needles and introducing the endoscopic stapling gun.

Depending upon the surgeon's comfort level, two to three accessory trocars are placed in the usual fashion: During the transperitoneal approach, one trocar is placed in the midline, midway between the umbilicus and pubic symphysis. One to two additional trocars are placed lateral to the inferior epigastric vessels, halfway between the anterior iliac spine and the umbilicus (Figure 2.). Trocar placements during the extraperitoneal technique are logically similar, but limited to the outer visual limits of the insufflated retroperitoneal space.

TRANSPERITONEAL ENTRY

Advantages and Disadvantages

Advantages of the transperitoneal approach to the space of Retzius include the ability to concomitantly correct other pelvic pathology by laparoscopy, to visualize and correct other defects in pelvic support, and to perform a prophylactic culdoplasty. Relative disadvantages include the need for general anesthesia, Trendelenburg positioning, the inherent risk of injury to visceral and vascular structures, the potential for aborting the procedure secondary to dense intraabdominal adhesions, the risk of bladder injury secondary to entering the retropubic space by incision of the supravesical peritoneum, and the physiologic sequelae and postoperative pain related to pneumoperitoneal carbon dioxide.

Technique

After placing the trocars in the usual fashion, the patient is placed in a 20 degree Trendelenburg position. The laparoscope is inserted and the pelvic viscera and trocar sites are inspected for injury. Surgery is performed to correct other pelvic pathology.

Prior to incising the anterior peritoneum to enter the retropubic space, the superior extent of the bladder dome can be ascertained by temporarily inflating the bladder with 200cc of saline or sterile milk. Using the urachus to identify the midline, the anterior abdominal wall peritoneum is grasped approximately 1 inch above the pubic symphysis and incised transversely using monopolar endoscopic scissors or laser energy, and extended laterally to both
of the obliterated umbilical ligaments. Care must be taken to avoid transecting the inferior epigastric vessels as they course parallel to these structures.

Once entered, the retropubic space can be opened down to the pubic symphysis by a combination of gentle blunt and sharp dissection using curved monopolar electrosurgical scissors, the irrigator probe, the laparoscope, aquadissection, an endoscopic Kittner sponge, or laser energy. To prevent troublesome pooling of blood and staining of tissues, hemostasis should be meticulous by discrete identification of blood vessels and prophylactic coagulation with monopolar or bipolar electrosurgery. Staying close to the back of the pubic bone, the space is progressively dissected to sequentially separate the anterior bladder, vaginal wall, and urethra downward.

Digital pressure within the vaginal vault is used to facilitate further dissection. Two fingers are placed in the vagina, one on each side of the catheterized urethra, to elevate the fornices in order to identify the urethrovaginal junction and underlying pubocervical fascia.

Starting laterally, the bladder is dissected medially and upward from the underlying fascia by using blunt dissection over the surgeons fingers as the vagina is displaced anteriorly and laterally. This can be accomplished either by static digital traction and active endoscopic blunt dissection, or by static endoscopic traction and active traction with the surgeon’s fingers. It is imperative to protect the delicate neurovascular plexus and musculature at the urethrovaginal junction by keeping all dissection 1-2cm lateral to the urethra, and to avoid the rich thin walled vascular plexus around the urethra.

To promote scarification, fibrofatty tissue can be cleared from the vaginal wall as it is dissected to expose the underlying pubocervical fascia and removed through an accessory trocar. Since it is highly vascular, prevesical fat is best dissected with the help of electrosurgery or laser energy. Using the aberrant and primary obturator vessels as the outer limits of dissection, preparation of the retropubic space is completed by identifying Cooper's ligament bilaterally and clarifying excessive fat and areolar tissue. The space is actively lavaged and hemostasis accomplished with directed bipolar desiccation.

**EXTRAPERITONEAL APPROACHES**

**Advantages and Disadvantages**

The comparative advantages of the extraperitoneal approach include the ability to use regional anesthesia and supine patient positioning, unhindered entry into the retropubic space in the presence of significant intraabdominal adhesions, entering the retropubic space by blunt dissection, the reduced risk for herniation at trocar sites, the virtual elimination of the risks from peritoneal entry, decreased operating time, and reduced postoperative pain. Relative disadvantages of this approach include the cost of disposable mechanical devices, lower accessory trocar positions, potentially difficult deep rectus dissection in obese patients, failure to enter the retropubic space secondary to scarring of the abdominal wall after prior laparotomy, and the inability to perform a prophylactic culdoplasty. Furthermore, the space of Retzius may become physically obstructed by a protuberant pneumoperitoneum accidentally created by peritoneal entry during the dissection of the preperitoneal space. Once recognized, the obstruction can be reduced by placing a small trocar into the peritoneal cavity to continuously vent the intraperitoneal carbon dioxide. In some cases, conversion to a transperitoneal approach will be necessary.

**Techniques**

Extraperitoneal entry into the space of Retzius can be accomplished using either blunt operative dissection or disposable balloon distention systems. Once the retropubic space is surgically or mechanically developed, further mobilization of the bladder, urethra, and
paravaginal tissues is accomplished using the same surgical techniques described for the transperitoneal approach. While the factors affecting trocar size and anatomic positions are similar to the transperitoneal technique, trocar placements are limited by the lateral and superior extent of the insufflated retropubic space.

Blunt surgical dissection into the retropubic space is initiated at the umbilicus. A several centimeter subumbilical skin incision is made transversely and carried into the subcutaneous tissues. The rectus fascia is cleared, incised transversely, and suture tagged at both edges for countertraction and to affix a Hasson trocar. Using the index finger, the subrectus preperitoneal space is bluntly dissected toward the symphysis pubis in the midline. A Hasson trocar is then inserted and secured in the usual fashion. A conventional or operating laparoscope is directed into the preperitoneal space which is insufflated and initially dissected with carbon dioxide at a setting of 8-10mm of Hg. Under direct vision the laparoscope is advanced over the anterior surface of the posterior rectus sheath to the midline of the pubic symphysis. The retropubic space is bluntly cleared of areolar tissues using the laparoscope or instruments inserted through the operating channel. Alternatively, after externally identifying the midline of the symphysis pubis as an anatomic target, the laparoscope is aimed and blindly advanced horizontally along the preperitoneal space into the space of Retzius. The space is then dissected by sweeping the laparoscope bilaterally in a slightly curvilinear fashion.

The space of Retzius can also be approached in an extraperitoneal fashion after completion of a laparoscopic procedure. The laparoscope is withdrawn into the subumbilical preperitoneal space, and under vision redirected caudally to progressively dissect the areolar tissue above the posterior sheath into the retropubic space. Using the laparoscope to alternatively visualize intraperitoneal and extraperitoneal sites, each accessory trocar is withdrawn from the peritoneal cavity and tunneled into the space of Retzius.

Mechanical balloon distention systems are an efficient method to bluntly and atraumatically dissect the retropubic space. The Preperitoneal Distention Balloon System (Origin Medsystems/Menlo Park, Ca.) consists of a trocar system preloaded with an inflatable balloon (Figure 4.). After creating a 10mm vertical or elliptical infraumbilical incision, the preperitoneal space is sharply entered and digitally developed as performed in blunt surgical dissection. The trocar system is lubricated at its distal end, and inserted beneath the underbelly of the rectus muscle. While staying in a horizontal plane, the preperitoneal space is gently dissected downwards aiming toward the posterior symphysis pubis. The balloon is then inflated by attaching a bulb to the head of the trocar, and a laparoscope is inserted after removing the obturator. Under direct vision, the balloon is further inflated to its maximum dimension. After 2 minutes, the balloon and laparoscope are removed as the space is slowly deflated. A 10mm Blunt Tip Trocar (Origin Medsystems) carrying a 30cc balloon is inserted into the developed preperitoneal space. After inflation, it is fixed in position by sliding and locking an external collar against the skin of the abdominal wall. The laparoscope is inserted after removal of the obturator and the space is insufflated with carbon dioxide at a setting of 8-10mm of Hg.

The Spacemaker Balloon Dissector (General Surgical Innovations/Portola Valley, Ca.) uses a balloon that is expanded with saline to bluntly dissect the retropubic space. It is a one piece design system with a premounted guide rod used to control the position of the balloon and maintain access to the dissected space (Figure 5.). It differs from the Origin device by being nondistensible and preshaped to anatomically conform to the retropubic space. After entry into the preperitoneal space, the device is inserted and tunneled toward the pubic symphysis. The plastic trocar sheath that houses the balloon is removed, leaving it and the mounted guide rod in the preperitoneal space. The balloon is expanded to its maximum diameter with 750cc of saline solution causing it to unroll sideways and dissect the retropubic
space first laterally, and then anteriorly and superiorly. After one minute of resting time, the balloon is aspirated via standard wall suction and removed. The trocar is then advanced over the guide rod and secured with a skin seal. After removing the guide rod a laparoscope is placed in the trocar and the space is insufflated at 8-10 mm of Hg.

METHODS FOR COLPOSUSPENSION

Suturing Techniques

After adequate mobilization of the urethra and fascial attachments of the bladder from the underlying pubocervical fascia, laparoscopic retropubic colposuspension is performed using the same time-honored principles practiced during the laparotomic technique. Both O-Vicryl and O-Ethibond on a CT-2 needle (Ethicon/Summerville, N.J.) or #2 Gorex on a THX-26 needle (W.L. Gore/Flagstaff, Arizona) can be used as suture materials. Proponents of using permanent suture argue that retropubic fibrosis and scarring are maximized by using materials with greater longevity. Both types of needles can be passed down the sheath of a 10-11 mm trocar by grasping the suture strand with a needle holder 2cm from the swedge point and passing it through the cannula into the surgical field.

Larger curved needles or smaller trocar sheaths can be accommodated by passing the needle directly into the surgical field. After removing the trocar sleeve from the abdominal wall, a needle holder is inserted into the sleeve and the terminal end of the suture is pulled up and out of the sheath. The needle holder is reinserted and the suture is grasped 2-3cm from the swedge point. Any suture slack is reduced by gentle traction on the terminal end. The needle holder is then inserted directly through the abdominal incision with the curved needle following in step. The trocar sleeve is then pushed back into the abdominal wall over the needle holder. The needle is then properly positioned into the needle holder with the help of the assistant.

Before suturing the vagina, it should be digitally lifted upward and forward to confirm that the mobility of the urethrovesical junction is adequate for repositioning to its normal location. Laparoscopic suturing is least encumbered when the available area of the anterior vaginal wall is maximized. This is best accomplished by elevating the fornix anterolaterally while the bladder and proximal urethra are simultaneously displaced medially using a blunt probe from the midline or contralateral port.

The suture needle is placed into the surgical field using a midline 10-11 mm or contralateral 5mm port (Figure 2.). Two sets of full thickness figure-of-eight stitches are sequentially placed into the vagina just short of the mucosa, driven into Cooper’s ligament and tied extracorporeally. Although suturing into the pubocervical fascia can be adequately performed through the midline or contralateral trocar ports, using the needle holder through a port ipsilateral to Cooper's ligament provides the best leverage for driving, turning, and bringing the needle out of this fibrous structure by permitting a perpendicular angle of attack.

Guided by the surgeon’s or assistant’s first and second fingers in the elevated vaginal fornix, the first stitch is placed distally, 1-2cm opposite the midurethra, and driven through the tissue mediolaterally in order to minimize the chance for urethral injury (Figure 7.). A sterile sewing thimble can be used to protect against accidental needle injury. Bleeding from perforation of the large veins that run along the vaginal wall is usually controlled when the sutures are tied. If the suture penetrates the vaginal canal, the mucosa will grow over it and tension will inevitably pull it away.

After securing the vagina, the suture is driven through Cooper's ligament in an anteroposterior direction, immediately above the location of the vaginal wall stitch (Figure 8.). The suture is then tied extracorporeally with an endoscopic knotpusher by passing 4-6
Brill Laparoscopic Retropubic Colposuspension Procedures

alternating hitches to secure vaginal elevation as the assistant pushes his or her fingers upward toward Cooper's ligament (Figure 9.). Alternatively, a double-clinch slip knot as described by Weston (14), which can be locked at any point, is tied outside of the trocar and pulled into the retropubic space to be cinched into position as the vagina is digitally elevated. Excessive tension must be avoided to reduce the risk of necrosis at the suture site, suture release, and compressing or kinking the urethra; the vaginal wall should not come in contact with Cooper's ligament, and the urethra drawn no closer than one centimeter to the symphysis pubis. A second proximal stitch is similarly placed into the vagina cephalad and lateral to the first, 1-2cm lateral to the urethrovaginal junction, driven through Cooper’s ligament (carefully noting the well perfused aberrant obturator vessels) and tied. The colposuspension is completed by repeating all steps with another set of sutures on the contralateral side.

The techniques used for removing needles from the retropubic space are dictated by the needle size and the diameter of the largest trocar sheath. Before tying to Cooper's ligament, a CV-2 or THX-26 needle is removed by reversing the order of events used for their insertion through a 10-11 mm trocar. When using larger curved needles or smaller trocars, each needle is cut off, leaving 4cm of attached suture, and temporarily set in the retropubic space. The freed strand is grasped and pulled out of the trocar sheath. After tying, each needle is removed by grasping the end of the suture tail and removing the trocar sheath, grasper and needle together with one continuous motion out of the abdominal wall. (29)

Suturing and Lateral Stapling

Suturing into Cooper's ligament, for many physicians the most difficult technical task during laparoscopic colposuspension, is eliminated by using endostaples to affix the lateral suture strand to this ligamentous structure. (28) After placing the suture into the vaginal fascia, the lateral suture arm is grasped by the assistant and laid flat along Cooper's ligament directly above the vaginal suture site (Figure 10.). The suture is secured to the ligament with 2-3 staples by using the EMS Endostapler (Ethicon/Endosurgery, Cincinnati, Ohio) through the midline 10-11mm trocar. (Figure 2.), The staples function as a pulley to elevate the vaginal wall as the suture is removed. Each suture is tied extracorporeally with an endoscopic knotpusher or using a double-clinch slip knot.

Colposuspension Using Prolene Mesh

The use of suturing to perform a laparoscopic colposuspension is entirely eliminated by using a laparoscopic stapling gun to secure a piece of Prolene mesh as a permanent suspensory hammock between the vagina and Cooper's ligament. (24) Despite appearing to significantly deviate from traditional teaching, this technique preserves the fundamental surgical principles of retropubic colposuspension.

Prolene mesh has been successfully used by general surgeons for over 20 years to perform open, and more recently laparoscopic herniorrhaphy without significant morbidity. Used in the retroperitoneal space, this material is highly inert, essentially nonallergenic, and withstands infection. (31) The fine double-knitted construction beneficially promotes fibroepithelial invasion and fixation among its interstices (32), stimulating retropubic scarring and fibrosis that should be sustained. This obviates the need to tediously remove the well vascularized retropubic fat to promote scarification.

Two strips of Prolene mesh, 1.5 x 5-6cm, are prepared with scissors and bathed in a cephalosporin solution to minimize the chance of introducing infection. Each strip is then grasped and introduced into the prepared retropubic space through a contralateral trocar port. While the assistant holds the distal end of the strip with a grasper, it is flattened and held parallel to the urethra. The surgeon displaces the vaginal fornix anterolaterally to identify the areas for
attachment while the mesh is stabilized. The EMS Endostapler is placed through the ipsilateral 10-11mm trocar (Figure 2.) and the stapler head is positioned over the distal mesh 1-2cm lateral to the midurethra. Two staples are fired into the pubocervical fascia. The proximal end of the strip is then stabilized by the assistant and two more staples are fired into the vagina 1-2cm lateral to the urethrovaginal junction (Figure 11.). This procedure is repeated on the contralateral side using the same trocar port logic. Before affixing the segments of mesh to Cooper's ligament, cystoscopy can be performed to inspect for staples in the bladder wall. If encountered, staples can be laparoscopically removed with an Endopath Endoscopic Staple Remover (Ethicon Endosurgery, Cincinnati, Oh.).

While digitally tenting the vaginal fornix toward Cooper's ligament, the proximal end of the mesh is grasped and placed on tension over the ligament above the site of attachment adjacent to the urethrovaginal junction. A lubricated Q-tip can be placed in the urethra to help guide the degree of vaginal elevation. Traction is terminated on attaining a horizontal angle. The surgeon should strive to leave at least a one centimeter gap between the urethra and pubic symphysis, which is fortuitously the approximate diameter of the endostapler nose. The stapling gun is placed through the contralateral 10-11mm port (Figure 2.), and with the head over the mesh three more staples are fired into Cooper's ligament (Figure 12.). This is repeated on the contralateral side in a similar fashion. Excess mesh is trimmed away with scissors and removed through the trocar sheath.

Concerns about potentially adverse effects of metal staples in the vaginal wall are logically unfounded. The firing mechanism of the endoscopic stapling gun is duplex, initially extending the arms of the staple followed by rapid enfolding. This essentially prevents entry into the vaginal canal. In the rare instance of transmural application, they will become well epithelialized just like suture materials. The widespread use of titanium staples in general surgery has consistently demonstrated their inertness and lack of migratory sequelae. Furthermore, the forces of tension tending to pull the staples out will always be directed cephalad. Downward forces exerted on the mesh by increases in abdominal pressure will be opposed by the tenacious hold of the staples to Cooper's ligament. Therefore, any movement of the paravaginal staples should be upward and away from the vaginal vault.

Closure

On completion of the colposuspension, the retropubic space is thoroughly lavaged to remove clots and tissue debris, and assessed for hemostasis under varying degrees of insufflation pressure or by underwater examination. Bleeding points are coagulated with bipolar desiccation. A suprapubic catheter can be placed under direct vision. The transperitoneal approach is completed by closing the peritoneal defect with 2-0 or 3-0 absorbable suture in a pursestring fashion or with the remaining endostaples. Cystoscopy may be performed to evaluate the integrity of the ureters (preceded by intravenous injection of 5cc of indigo carmine) and to rule out the presence of sutures or staples in the bladder wall. On withdrawal of all instruments from the surgical field and peritoneal cavity, fascial and subcutaneous stitches are placed at all trocar sites larger than 10mm, and adhesive strips across all 5mm trocar sites.

ADJUNCTIVE REPARATIVE SURGERIES

A prophylactic culdoplasty can be performed in conjunction with a retropubic colposuspension. The incidence of postoperative enterocoele formation after retropubic colposuspension has been reported to range from 3-17%.[33] This is due to a number of factors which include the effects of altering the axis of the posterior vaginal wall in relation to abdominal pressure, intrinsic collagen deficiencies, and the presence of unrecognized early vault prolapse.
Laparoscopic culdoplasty requires the use of a transperitoneal approach, and for maximal surgical access should be performed prior to the colposuspension. The cul-de-sac is obliterated by using permanent suture materials that are tied extracorporeally. Culdoplasty can be accomplished using either a modified McCall procedure (34) by placing several stitches to plicate the uterosacral ligaments side to side while incorporating the peritoneum of the cul-de-sac, or a Moschowitz procedure (35) to concentrically occlude the cul-de-sac by successively taking bites of the lateral pelvic peritoneum, anterior serosa of the rectum, and peritoneum of the cul-de-sac. Both procedures require careful identification of the ureters to prevent entrapment or kinking.

Laparoscopic entry into the space of Retzius provides an invaluable opportunity to evaluate the endopelvic fascia for lateral avulsion of the anterolateral vaginal sulcus from the arcus tendineus fasciae pelvis. Pneumoperitoneal pressure in the retropubic space serendipitously accentuates these defects. Failure to concomitantly repair associated lateral weaknesses of the endopelvic fascia condemns the patient to incompletely corrected anterior vaginal wall prolapse and may decrease the longevity of the urethropexy by colposuspension. If a lateral herniation is noted, the paravaginal defect can be repaired in a fashion similar to that originally described by A. C. Richardson. (36) The vaginal wall is digitally placed on medial traction to accentuate the defect and maximize surgical access. Beginning one centimeter above the ischial spine, 4-5 figure-of-eight stitches are successively placed to restore the attachment of the paravaginal tissue to the fascia overlying the obturator internus muscle and tied extracorporeally.

Anterior herniations of the endopelvic fascia are commonly found in association with other defects in pelvic support. Any clinically significant rectocele or enterocele should be repaired by the usual surgical approach. The longevity of a retropubic colposuspension is inherently related to the surgical correction of these associated pelvic floor herniations.
REFERENCES


Complications of Gynecological Laparoscopy

Malcolm G. Munro M.D.
Professor
Department of Obstetrics & Gynecology
University of California, Los Angeles
INTRODUCTION

Gynecological laparoscopic procedures are similar to any other interventions - despite all efforts to the contrary, adverse clinical outcomes may occur. Some complications are minor, and have little effect on the patient's short or long term surgical result. However others may be of greater consequence and undermine the expectations of the patient and her health care providers. Gynecologists have been performing laparoscopic procedures longer and in greater volume than any other group of physicians. The relatively large body of literature reflecting this experience is principally comprised of reports of diagnostic and minor operative procedures, most notably female sterilization. The reported incidence of minor and major complications ranges from 1 to 4 percent and 0.3 to 2.8 percent respectively. However, many of these reports are potentially biased voluntary surveys, and, because most focus on minor procedures, the risk of complications for the more advanced and complicated operative procedures, introduced to North America in the 1980s, is likely underestimated.

The German literature may provide a glimpse into the future as, in that country, operative laparoscopy has enjoyed a longer history of use. From 1949 to 1988 the death rate has steadily declined from 0.09 percent (1949-77) to 0.008 percent (1986-88). The serious complication risk started at 3.56 percent between the years 1949-77 but now ranges from 1.93 percent to 2.36 percent. However, again, these data are collected by self reporting techniques that may not accurately reflect risk.

Consequently, although most of the complications associated with diagnostic and operative gynecological laparoscopy are known, because of the existent reporting mechanisms, their frequency is currently impossible to measure. The difficulty is compounded by the rapid increase in the number of procedures, introduction of new equipment, and the plethora of new, variably trained and often inexperienced technicians. This chapter will first consider the types of complications potentially encountered, focusing on those that may be more frequently encountered or unique to gynecologic laparoscopy. Then, a procedure-specific section will address how these complications can involve selected gynecologic operations that can be performed under laparoscopic guidance.

TYPES of COMPLICATIONS

MEDICAL AND ANESTHESIA

One third of the deaths associated with minor laparoscopic procedures such as sterilization are secondary to complications of anesthesia. Among the potential complications of all general anesthetics are hypoventilation, esophageal intubation, gastroesophageal reflux, bronchospasm, hypotension, narcotic overdose, cardiac arrhythmias and cardiac arrest. Laparoscopy, when performed with CO$_2$ or N$_2$O insufflation, induces change in a number of parameters of cardiopulmonary function including reduced pO$_2$, O$_2$ saturation, tidal volume and minute ventilation, as well as an increased respiratory rate. The use of intraperitoneal CO$_2$ as a distension medium is associated with an increase in pCO$_2$ and a decrease in pH. Elevation of the diaphragm may be associated with basilar atelectasis, a resulting right to left shunt and a ventilation perfusion mismatch.

Gynecologic laparoscopy poses a number of inherent features that can enhance some of these risks. For example, the head down (Trendelenburg's) position, in combination with the increased intraperitoneal pressure provided by pneumoperitoneum, places greater pressure on the diaphragm, and potentiates hypoventilation, with its resulting hypercarbia and metabolic acidosis. This position, combined with anesthetic agents that relax the esophageal...
Carbon Dioxide Embolus

Carbon dioxide is the most widely used peritoneal distension medium. The vast majority of CO\(_2\) microemboli are absorbed, usually by the splanchnic vascular system, quickly and without incident. However, severe cardiorespiratory compromise may result if large amounts of CO\(_2\) gain access to the central venous circulation, such as with inadvertent intravascular placement of an insufflation needle.

**Diagnosis**

The presenting signs of CO\(_2\) embolus include sudden, otherwise unexplained hypotension, cardiac arrhythmia, cyanosis and the development of a classical "mill-wheel" heart murmur. Other clinical sequelae include an increased tidal CO\(_2\), findings consistent with pulmonary edema, and pulmonary hypertension, resulting in right-sided heart failure.

**Risk Reduction**

A number of steps may be taken to reduce the risk of CO\(_2\) embolus. Since most gynecological surgeons preinflate the peritoneal cavity with an insufflation needle, it is important to ensure that blood is not emanating from the needle prior to introducing the distending gas. The risk of CO\(_2\) embolus is also reduced by operating in an environment where the intraperitoneal pressure is always less than 20 mm Hg. In most instances, excepting the initial placement of trocars in an insufflated peritoneum, the surgeon should be able to function comfortably with the intraperitoneal pressure between 8 and 12 mm Hg. Such pressures may also provide protection from many of the other adverse cardiopulmonary events described below. The risk of CO\(_2\) embolus is further inhibited by the meticulous maintenance of hemostasis, for open venous channels are a portal of entry for gas into the systemic circulation. Another option that should virtually eliminate the incidence of CO\(_2\) or other gas emboli is the use of "gasless" or "apneumic" laparoscopy, where extra or intraperitoneal lifting mechanisms are used to create a working space for the surgeon. Such devices have yet to be widely accepted in the gynecological community.

**Management**

When CO\(_2\) embolus is suspected or diagnosed, the operating room team must act quickly. The surgeon must immediately decompress the peritoneal cavity and place the patient's head below the level of the right atrium, in the Durant, or left lateral decubitus position. Immediately establishment of a large bore central venous line may allow aspiration of gas from the heart. Because the findings are non specific, other causes of cardiovascular collapse should be considered.

**Cardiovascular Complications**

Hypercarbia and the resulting acidemia are the principal reasons for the relatively frequent development of cardiac arrhythmias during the performance of laparoscopic surgery. The initial reports of laparoscopy-associated arrhythmia were in association with spontaneous respiration, leading most anesthesiologists to adopt routine mechanical ventilation. The anesthesiologist must be careful to select agents that limit the risk of cardiac arrhythmia.
Complications of Gynecological Laparoscopy

The incidence of hypercarbia associated arrhythmias may be reduced by operating with intraperitoneal pressures that are less than 12 mm Hg. The use of an alternate intraperitoneal gas such as NO₂ may reduce hypercarbia, but it is insoluble in blood and is associated with an increased severity of post-operative shoulder tip pain. Apneumic techniques are a useful option, particularly for those patients at increased risk for cardiac arrhythmias.

While at laparoscopy the most common cause of low blood pressure is hemorrhage, hypotension can also occur secondary to excessive intraperitoneal pressure resulting in decreased venous return, and resulting decreased cardiac output. This undesirable result may be potentiated if the patient is volume depleted. Hypotension secondary to cardiac arrhythmias may also be a consequence of vagal discharge in response to increased intraperitoneal pressure. All of these side effects will be more dangerous for the patient with preexisting cardiovascular compromise.

Gastric Reflux

Gastric regurgitation and aspiration are complications potentiated by laparoscopic surgery, especially when performed in Trendelenberg’s position. Other factors that increase risk include obesity, gastroparesis, hiatal hernia or any type of gastric outlet obstruction. In such patients it is important to quickly secure the airway with a cuffed endotracheal tube and to routinely decompress the stomach with a nasogastric or orogastric tube. The surgeon can contribute to aspiration prophylaxis by operating at the lowest necessary intraperitoneal pressure. Patients should be taken out of the Trendelenburg position prior to being extubated. The adverse effects of aspiration may be minimized with the routine preoperative administration of metoclopramide, H₂ blockers and nonparticulate antacids.

SOFT TISSUE EMPHYSEMA

Subcutaneous emphysema most commonly results from preperitoneal placement of an insufflation needle or leakage of CO₂ around the cannula sites, the latter frequently because of excessive intraperitoneal pressure. While the condition is usually mild and limited to the abdominal wall, it can become extensive, involving the extremities, the neck, and the mediastinum. Another relatively common location for emphysema is the omentum or mesentery.
Complications of Gynecological Laparoscopy

Diagnosis

Often the diagnosis will not be a surprise, for the surgeon may have had difficulty in positioning the insufflation needle and/or primary cannula within the peritoneal cavity. Subcutaneous emphysema may be readily identified by the palpation of crepitus in the abdominal wall, and if it extends along contiguous fascial plains to the neck, it can be visualized directly. Such a finding can be a reflection of the development of mediastinal emphysema, which, if severe, may lead to pneumothorax and cardiovascular collapse.

Risk Reduction

The risk of subcutaneous emphysema is reduced by proper positioning of an insufflation needle, if it is used at all. No one test absolutely predicts intraperitoneal placement - instead, a variety should be used, including aspiration, creation of preinstillation negative pressure, and maintenance of low insufflation pressure with symmetrical distension of the abdominal wall. Preinflation negative pressure can be demonstrated by aspirating a drop of water placed on the open end of the insufflation needle, followed by elevation of the anterior abdominal wall. A more quantitative demonstration is to elevate the abdominal wall after the tubing is connected to the needle; the result should be a low or negative intraperitoneal pressure as measured by the digital gauge of the insufflator (-1 to -4 mm Hg). Insufflation should be initiated at a low flow rate (1 liter/minute) until the surgeon has confidence that proper placement has been achieved. Loss of liver dullness should occur when about 500 cc of gas has entered the peritoneal cavity. The distension should be symmetrical and the measured intraperitoneal pressure should be below 10 mm Hg; sometimes slightly higher in patients. If, at any time, the surgeon feels that the needle is not located intraperitoneally, it should be withdrawn and reinserted. Once the peritoneal cavity has been insufflated with an adequate volume of gas, the primary trocar is introduced. The laparoscope is introduced, and, if the cannula is satisfactorily located, the tubing is attached to the appropriate port.

Subcutaneous emphysema may evolve despite intraperitoneal placement of the trocars, an event that can be avoided by maintaining a low intraperitoneal pressure following the placement of the desired cannulas, at least below 15 mm Hg and preferably near 10 millimeters Hg. Other approaches that may reduce the chance of developing subcutaneous emphysema include open laparoscopy and the abdominal wall lifting systems that render gas unnecessary. Although primary blind insertion of sharp trocars has been demonstrated to be as safe as secondary insertion, following pneumoinsufflation, the relative incidence of subcutaneous emphysema is unknown.

Management

If the surgeon finds that the initial insufflation has occurred extraperitoneally, there exist a number of options. While removing the laparoscope and repeating the insufflation is possible, it may be made more difficult because of the new configuration of the anterior peritoneum. Options include open laparoscopy or the use of an alternate site such as the left upper quadrant. One attractive approach is to visually direct insertion of the insufflation needle after leaving the laparoscope in the expanded preperitoneal space.

For mild cases of subcutaneous emphysema, no specific intra- or post-operative therapy is required, as the findings, in at least mild cases, quickly resolve following evacuation of the pneumoperitoneum. When the extravasation extends to involve the neck, it is usually preferable to terminate the procedure, as pneumomediastinum, pneumothorax, hypercarbia and cardiovascular collapse may result. Following the end of the operation it is prudent to obtain a
Hemorrhagic complications of laparoscopy may occur as a consequence of entry into the peritoneal cavity, or, as a result of trauma incurred to blood vessels encountered during the course of the procedure.

**Great Vessels**

The most dangerous hemorrhagic complications of entry are from injury to the great vessels, including the aorta and vena cava as well as the common iliac vessels and their branches, the internal and external iliac arteries and veins. The trauma most often occurs secondary to insertion of an insufflation needle, but catastrophic results may result from the tip of a sharp trochar inserted with closed technique. However, the insertion of ancillary laparoscopic ports into the lower quadrants may also be associated with damage, most frequently to the aorta and the right common iliac artery. The anatomically more posterior location of the vena cava and the iliac veins provides relative protection, but not immunity, from injury. While most of these injuries are small and amenable to repair with suture, some have been larger, requiring ligation with or without the insertion of a vascular graft. Not surprisingly, death has been reported in a number of instances.

**Recognition**

Most often the problem manifests in profound hypotension with or without the appearance of a significant volume of blood within the peritoneal cavity. In some instances, the surgeon aspirates blood via the insufflation needle, prior to introduction of the distending gas medium. Frequently the bleeding may be contained in the retroperitoneal space, a feature that usually delays the diagnosis. Consequently, the development of hypovolemic shock in the recovery room may well be secondary to an otherwise unrecognized laceration to a great vessel. To avoid the specter of late recognition, it is important to evaluate the course of each great vessel prior to completing the procedure.

**Risk Reduction**

There are a number of ways by which the incidence of large vessel trauma can be minimized. It has been suggested that the use of "open laparoscopy" for the initial port entirely avoids the issue of great vessel injury secondary to insufflation needles and trocars. While the incidence may be reduced, the author is aware that injuries to the vena cava have been incurred, likely due in part to the reduced exposure afforded by open laparoscopy. To prevent injury from the insertion of other ports, it is essential that the positioning of ancillary, or secondary, trocars in the lower quadrants be performed under direct vision.

The risk of large vessel injury with closed insertion should be reduced if careful attention is paid to equipment and technique. If used, both insufflation needles and the trochar should be kept sharp or should be disposable. The spring-loaded obturator of the insufflation needle should be checked to ensure that the sliding mechanism is functioning normally. Many disposable trochar-cannula systems are constructed with a "safety" mechanism that covers or retracts the trocar following passage through the fascia and peritoneum. However, there are currently no data demonstrating that these devices reduce the incidence of major vessel injury.
The application of appropriate technique is based upon a sound understanding of the normal anatomic relationships between the commonly used entry points and the great vessels. A "safety zone" exists inferior to the sacral promontory in the area bounded superiorly by the bifurcation of the aorta, posteriorly by the sacral curve and laterally by the iliac vessels. Safe insertion of the insufflation needle mandates that the instrument be maintained in a midline, sagittal plane while the operator directs the tip between the iliac vessels, anterior to the sacrum but inferior to the bifurcation of the aorta and the proximal aspect of the vena cava. Such positioning requires elevation of the abdominal wall while angling the insufflation needle about 45 degrees to horizontal. The tactile, visual and auditory feedback created when the needle passes through the facial and peritoneal layers of the abdominal wall, if recognized and heeded, may prevent overaggressive insertion attempts. Such proprioceptive feedback is diminished with disposable needles as compared to the classic Veress model. Instead, the surgeon must listen to the "clicks" as the needle obturator retracts when it passes through the rectus fascia and the peritoneum. The needle should never be forced.

It is critical to note that these anatomic relationships may vary with body type and with the orientation of the patient to the horizontal position. In women of normal weight and body habitus, in the horizontal recumbent position, the bifurcation of the aorta is located immediately beneath the umbilicus. However, in obese individuals the umbilicus may be positioned up to two or more centimeters below the bifurcation (Figure 1). This circumstance dictates that the insufflation needle be directed in a more vertical position. For those women between 160 to 200 pounds the angle should be between 45° and 90°, and in those women over 200 pounds it should be nearly 90°. Women placed in a "head-down" position (Trendelenberg's Position) will shift their great vessels more superiorly and anteriorly in a fashion that may make them more vulnerable to an entry injury. Consequently, positioning of the insufflation needle, and at least the initial trocar and cannula, should be accomplished with the patient in a horizontal position. The risk of great vessel injury is likely reduced by temporarily insufflating the peritoneal cavity to an intraperitoneal pressure of 20 millimeters of mercury, which can aid in separating the abdominal wall from the great vessels during the process of insertion of a sharp trocar.

Management

If blood is withdrawn from the insufflation needle, it should be left in place while immediate preparations are made to obtain blood products and perform laparotomy. If the diagnosis of hemoperitoneum is made upon initial visualization of the peritoneal cavity, a grasping instrument may be used, if possible, to temporarily occlude the vessel. While it is unlikely that significant injury can predictably be repaired by laparoscopically directed technique, if temporary hemostasis can be obtained, and the laceration visualized, selected, localized lesions can be repaired, with suture, under laparoscopic guidance. Such an attempt should not be made by any other than experienced and technically adept surgeons. Even if such an instance exists, fine judgement should be used so as not to delay the institution of life saving, open surgical repair.

Most surgeons should gain immediate entry into the peritoneal cavity, and immediately compress the aorta and vena cava just below the level of the renal vessels, gaining at least temporary control of blood loss. At that juncture, the most appropriate course of action, including the need for vascular surgical consultation, will become more apparent.

Abdominal Wall Vessels
By far the most commonly injured abdominal wall vessels are the superficial inferior epigastrics as they branch from the femoral artery and course cephalad in each lower quadrant. They are invariably damaged by the initial passage of an ancillary trochar, or when a wider device is introduced later in the procedure. The problem may be recognized immediately by the observation of blood dripping along the cannula or out through the incision. However, it is not uncommon for the cannula itself to obstruct the bleeding until withdrawal at the end of the case.

More sinister are injuries to the deep inferior epigastric vessels, branches of the external iliac artery and vein that also course cephalad but are deep to the rectus fascia and often deep to the muscles themselves (Figure 2). More laterally located are the deep circumflex iliac vessels that are uncommonly encountered in laparoscopic surgery. Laceration of these vessels may cause profound blood loss, particularly when the trauma is unrecognized and causes extraperitoneal bleeding.

Recognition
Recognition is by visualization of the blood dripping down the cannula, or by the post operative appearance of shock, abdominal wall discolorization and/or a hematoma located near to the incision. In some instances the blood may track to a more distant site, presenting as a pararectal or vulvar mass. Delayed diagnosis may be prevented at the end of the operation with laparoscopic evaluation of each peritoneal incision following removal of the cannula.

Risk Reduction
Transillumination of the abdominal wall from within the peritoneal cavity, will, in most cases, allow for identification of the superficial inferior epigastric vessels. However, the deep inferior epigastric vessels cannot be identified by this mechanism because of their location deep to the rectus sheath. Consequently, prevention of deep inferior epigastric vessel injury requires that the surgeon understand the anatomic course of these vessels (Figure 2). At the pubic crest, the deep inferior epigastric vessels begin their course cephalad between the medially located medial umbilical ligament and the more laterally positioned exit point of the round ligament. The trocar should be inserted medial or lateral to the vessels, if they are visualized. If the vessels cannot be seen, and it is necessary to position the trocar laterally, it should be inserted three to four centimeters lateral to the median umbilical ligament. Too lateral an insertion will endanger the deep circumflex epigastric artery. The operator may further limit risk of significant injury by placing a No. 22 spinal needle through the skin at the desired location, directly observing the entry via the laparoscope. This not only provides more reassurance that a safe location has been identified, but the easily visualized peritoneal needle hole gives the surgeon a target for inserting the trocar with greater precision.

A common mistake is to fashion the skin incision appropriately, only to direct the trocar medially through the abdominal wall, thereby injuring the vessels. Another factor that may contribute to the risk of injury is the use of large diameter trocars and cannulas. Consequently, for this and other reasons, it behooves the surgeon to use the smallest cannulas necessary for performance of the procedure.

Management
Superficial inferior epigastric artery lacerations usually respond to expectant management. Rotation of the cannula to a position where compression is possible is also helpful. Rarely is a suture necessary.
For the ligation of lacerated deep inferior epigastric vessels I have found that the use of a modified, straight ligature carrier is most useful. Following removal of the trocar and cannula, the ligature carrier is used to advance a suture under laparoscopic guidance, directing it laterally and inferiorly, where it is held by a grasping forceps. The ligature carrier is removed and subsequently passed through the incision again, without a suture, but this time medial and inferior to the lacerated vessels. The suture is threaded into the carrier from within the peritoneal cavity, and is then externalized and tied. For small incisions, narrower than the diameter of the surgeon's finger, the knot may be tightened with a laparoscopic knot manipulator.

There are other, less uniformly successful methods for attaining hemostasis from a lacerated deep inferior epigastric vessel. The most obvious is the placement of large, through-and-through mattress sutures usually removed about 48 hours later. Electrodesiccation can occasionally be successful, as may temporary compression with the balloon of a Foley catheter, passed through the incision into the peritoneal cavity, then secured and tightened externally with a clamp. While some suggest that the balloon should be left in place for 24 hours, the delicate channel may be damaged by the clamp making it impossible to deflate the balloon. For this reason, the author does not recommend this option.

If the lacerated vessel presents post operatively as a hematoma, the initial efforts should be with local compression. The temptation to open or aspirate the hematoma should be resisted, as such a maneuver may inhibit the tamponade effect and could increase the risk of abscess formation. However, if the mass continues to enlarge, or if the patient demonstrates signs of hypovolemia, wound exploration is indicated.

As with any intraperitoneal surgical procedure, hemorrhage may occur from injury to vessels encountered in the course of the surgical dissection. The bleeding may result from inadvertent entry into a vessel or failure of a specific occlusive technique.

Recognition

Usually, recognition of an injured vessel is immediate and obvious. However, delayed recognition of hemorrhage is common following transection of arteries because of the transient vasospasm. In addition, there may be further delay in diagnosis at laparoscopy because of the restricted visual field and the temporary occlusive pressure exerted by the CO\textsubscript{2} within the peritoneal cavity. Consequently, at the end of the procedure, all areas of dissection should be carefully examined. In addition, the CO\textsubscript{2} should be vented, decreasing the intraperitoneal pressure to about five mm Hg, allowing recognition of vessels occluded by the higher pressure.

Risk Reduction

During dissection, vessels should be identified and occluded prior to division, a task made more simple by the magnification afforded by the laparoscope. If suture is used to occlude a vessel, it must be of the appropriate caliber, positioned with an adequate pedicle and tied snugly with a secure knot. Electrosurgical coagulation, if used, should be applied in the appropriate wave form and power density, and for a time adequate to allow for sufficient tissue desiccation. Clips should be of a size appropriate for the vessel, and they must applied in a secure fashion, also with an adequate pedicle of tissue. The surgeon should avoid manipulation of pedicles secured with clips or suture as such trauma could adversely affect the security of the closure. When linear stapling devices are employed, the appropriate staple size should be selected and the tissue encompassed in the staple line should be of uniform thickness. Failure to
Munro Complications of Gynecological Laparoscopy

maintain relatively uniform tissue thickness may result in inadequate compression of blood vessels that course through the thinner areas of the pedicle.

Management

Transected vessels should be secured immediately. There is evidence that arteries larger than three millimeters in diameter are less reliably occluded with desiccation than are those three millimeters or less. If bipolar electrosurgical desiccation is used to maintain or achieve hemostasis, the use of a serial ammeter is useful to demonstrate the end point of energy application. Blind clamping followed by electrosurgical desiccation must be avoided, even with bipolar instruments, especially when less than one centimeter from ureter or bowel. When a vessel is in such a location, it is usually preferable to secure it with a clip.

Identification of small vessel bleeding and ooze is often facilitated by the use of copious irrigation and even underwater examination. Capillary ooze may be managed with higher voltage fulguration currents, most effectively using electrodes with a dome-shaped tip. When using electrosurgery for this purpose, the use of electrolyte containing solutions should be avoided as they disperse current rendering the technique ineffective. Instead, low viscosity fluids like glycine are recommended as, in addition to being non conductive, they may facilitate tracking of the current to the bleeding vessels.

GASTROINTESTINAL COMPLICATIONS

Gynecological pathology is frequently intimately associated with the bowel, making the gastrointestinal tract vulnerable to injury from related dissection. Gastrointestinal viscera can also be injured when performing "open laparoscopy", or with the blind or directed passage of needles and sharp trocars into the peritoneal cavity.

Insufflation Needle Injuries

Needle entry into the stomach occurs in the presence of gastric distension or when adhesions bind the stomach to the abdominal wall. While distension may occur secondary to aerophagia, the complication is frequently related to difficult or improper intubation or to the use of mask induction with an inhalation anesthetic. Mechanical entry into large or small bowel may occur in any instance, but is up to 10 times more common when laparoscopy is performed on patients with previous intraperitoneal inflammation or abdominal surgery. In such instances, loops of intestine can adhere to the abdominal wall under the insertion site. Perforation may also occur following an overly aggressive attempt to insert the insufflation needle.

Recognition

Recognition of gastric entry by the insufflation needle may follow identification of any or all of the signs of extraperitoneal entry, including increased filling pressure, asymmetric distension of the peritoneal cavity or the aspiration of gastric particulate matter through the lumen of the needle. However, the hollow, capacious nature of the stomach may allow the initial insufflation pressure to remain normal. Unfortunately, in some instances, the problem is not identified until the trocar is inserted and the gastric mucosa identified by direct vision. Recognition of bowel entry usually follows observation of the signs described above for gastric injury, with, in the case of colonic entry, the addition of feculent odor to the list of potential findings.

Risk Reduction
Complications of Gynecological Laparoscopy

Diminishing the frequency of insufflation needle injury to the gastrointestinal tract is important because such measures likely reduce the risk of more sinister trochar trauma. Gastric perforation can largely be eliminated with the use of preoperative oral- or nasogastric suction, either routinely for left upper quadrant insertions, or selectively when there has been difficulty with intubation.

Many have suggested that "open laparoscopy" is the most appropriate and effective way to reduce the incidence of intestinal injury in a patient at risk because of previous lower abdominal surgery. However, there are no studies that prove this to be the case. Indeed, there exists evidence that open laparoscopy is itself associated with intestinal injury. Consequently, many surgeons use the left upper quadrant insertion technique discussed previously, following adequate decompression of the stomach.

Although not strictly a prophylactic measure, the routine use of preoperative mechanical bowel preparation, at least in selected, high risk cases, will diminish the need for laparotomy and/or colostomy if large bowel entry occurs.

Management

The management of any trauma to the gastrointestinal tract depends in part upon the nature of the injury and in part upon the organ(s) involved. In general, insufflation needle punctures that have not resulted in a defect significantly larger than their diameter may be handled expectantly. Larger defects should be repaired or resected, by laparoscopic or laparotomy-based technique, depending upon the skill of the operator and the extent of the lesion.

If, following insertion of an insufflation needle, particulate debris are identified, the needle should be left in place and an alternate insertion site identified, such as the left upper quadrant. If the insufflation needle possesses a removable obturator, a narrow caliber optical fiber or laparoscope may be passed to evaluate the location of the tip and to aid in later identification of the puncture site. Immediately following successful entry into the peritoneal cavity, the site of injury is identified. Unless significant injury or bleeding are identified, the situation may be handled expectantly. If there is unexpected extension of the laceration, it should be managed similar to a trochar injury.

Trocar Injuries

Damage caused by sharp trocar penetration is usually more serious than when needle injury occurs. Most often, the injury is created by the primary trocar, because of its blind insertion. However, inadequate attention paid to the insertion of ancillary cannulas may also result in gastrointestinal injury.

Recognition

When a primary trocar inserted with closed technique penetrates bowel, the diagnosis is usually made when the surgeon visualizes a mucosal lining following insertion of the laparoscope. If large bowel is entered, a feculent odor may be noted. However, in some instances, the injury may not immediately be recognized as the cannula may not stay within, or it may pass through the lumen and out the other side of the viscus. Such injuries usually occur when a loop of bowel is adhered to the anterior abdominal wall near to the entry point. Consequently, it is important at the end of the procedure to directly view the removal of the primary cannula, either through the device itself or via an ancillary port. Unfortunately, the lesion may go unrecognized until it presents post operatively with peritonitis, abscess, enterocutaneous fistula or death.
Munro Complications of Gynecological Laparoscopy

Risk Reduction

Trocar injury to the stomach is largely eliminated with the liberal use of oral or nasogastric decompression. Bowel injuries usually occur when the intestine is adherent to the abdominal wall under the site of trocar insertion. Consequently, preoperative mechanical bowel preparation should be employed in high risk patients to facilitate repair of colonic injury without the need to perform a laparotomy.

Despite the widespread use of disposable cannula insertion systems with retractable trocars or "safety" sheaths, injury to bowel or other structures may occur. While many routinely employ open laparoscopy, bowel entry may still occur. An alternative approach, especially when entering an abdomen with previous laparotomy scars, is left upper quadrant insertion, preferably with an insufflation needle specially designed to allow passage of a narrow laparoscope (1.5 - 2 mm diameter). Such an approach allows direct visualization of the abdominal wall under the umbilicus or other planned site of insertion, and may facilitate dissection of any underlying adhesions.

Management

Trocar injuries to the gastrointestinal tract almost always require repair. If it can be ascertained that the injury is isolated, and if the operator is capable, the lesion may be repaired under laparoscopic guidance using appropriate suture. Extensive lesions may require resection and reanastomosis, which may be performed under laparoscopic direction, but in most instances will require laparotomy. If the injury is to sigmoid colon, primary repair may be attempted if the bowel has been mechanically prepared preoperatively. If uncertainty exists regarding the extent of injury, laparotomy is always indicated.

Dissection and Thermal Injury

Recognition

Any amount of dissected bowel should be carefully examined during the dissection, for comprehensive "running" of the bowel near the end of the case is far more difficult under laparoscopic guidance. Thermal injury to bowel may be more difficult to diagnose intraoperatively, particularly if created with electrical or laser energy, a feature that makes careful adherence to safety protocols a surgeon's imperative. Even if thermal injury is recognized, it is difficult to estimate the extent of the damage by visual inspection, as the zone of desiccation may exceed the area of visual damage. An understanding of the differing impacts of the various types of electrical current is essential for estimation of the extent of injury. In some instances, diagnosis is delayed until the development of peritonitis and fever, usually a few days later, but occasionally not for several weeks.

Risk Reduction

Absolute prevention of dissection or thermal injury is impossible, but the incidence of penetrating or energy-based enteric complications may be reduced with patience, prudence and meticulous technique. A sound understanding of the principles of electrosurgery is critical to reducing the incidence of electrical trauma.

When dissecting, adequate exposure of the operative field must be accomplished, frequently with the retraction and countertraction provided by a competent assistant. Dissection close to bowel should be performed mechanically, using sharp scissors; not with electrical or laser energy sources. Occlusion of blood vessels near to bowel is accomplished with clips, or bipolar current, provided that there is an adequate margin of tissue.
Munro Complications of Gynecological Laparoscopy

While there is no certainty about the proper electrode-bowel distance, animal histological studies, using large caliber Kleppinger forceps, have demonstrated that desiccation injury begins to affect bowel serosa and muscularis between 5 and 10 millimeters away. It is likely that the zone of safety is less for instruments that use electrodes with smaller surface area. Regardless, if the difficulty of the dissection makes the surgeon uncomfortable, alternative methods for hemostasis should be used. If this is not feasible, the aid of a more experienced colleague should be sought, or the procedure abandoned, or converted into an open case.

**Management**

The treatment of mechanical bowel trauma recognized during the dissection follows the principles described above for trocar injury. If the diagnosis is delayed until the postoperative recognition of peritonitis, expeditious laparotomy must be arranged.

Thermal injury may be handled expectantly, if, in the estimation of the surgeon, the lesion is superficial and confined. Wheeless reported a series of 33 individuals with such injuries who were followed expectantly in hospital. Only two required laparotomy for perforation. It is possible to estimate the degree of tissue injury if the nature of the current and other parameters are known, such as the wattage, current density and duration of contact with tissue. For example, fulguration current, arcing from a large electrode to bowel for a relatively limited period of time, is unlikely to cause thermal injury more than one millimeter deep. On the other hand, the high power density provided by arcing a sharp or pointed electrode will quickly cause penetrating injury of the bowel. Such lesions will have relatively little collateral thermal injury and may be repaired as if they were created by mechanical means. This is a circumstance vastly different from that which occurs when there is direct, and even relatively short duration of contact with an electrode providing relatively lower power density. The significant thermal injury that results will often mandate wide excision of the lesion or local resection of the injured segment of bowel.

**UROLOGIC INJURY**

Laparoscopy-associated damage to the bladder or ureter may occur secondary to mechanical or thermal trauma. In gynecological procedures, vesical injury is often secondary to a trocar entering the undrained bladder but may also occur during dissection of the bladder, either from other adhered structures or from the anterior aspect of the uterus. Laparoscopically directed retropubic suspension for urinary incontinence is a relatively new procedure, but is also associated with bladder injury, particularly when previous surgery compromises the dissection and visualization of normal anatomy. Ureteric injury is more commonly encountered secondary to thermal damage but may occur in association with mechanical dissection or the use of linear stapling devices. The author is aware of many other unreported cases of ureteric trauma.

**Recognition**

As with all visceral trauma, intraoperative identification of the injury is the most important aspect of management. The diagnosis is relatively easy if the surgeon recognizes entry into a hollow viscus or when urine is found in the operative field. Hematuria is suggestive of urinary tract injury and pneumaturia (CO₂ in the indwelling drainage system) is diagnostic of vesical entry. The existence of a bladder laceration may be confirmed with the injection of sterile milk or a dilute methylene blue solution via an indwelling catheter. Thermal injury to the bladder may not be initially apparent, and frequently presents later in the patient's postoperative course when the traumatized area sloughs off allowing the egress of urine into the peritoneal cavity.
Complications of Gynecological Laparoscopy

Ureteric lacerations may be proven intraoperatively with the systemic injection of indigo carmine. Intraoperative recognition of mechanical obstruction secondary to staples or suture can be made either by direct visualization of the occlusion, or when cystoscopic imaging fails to demonstrate injected indigo carmine dye entering the bladder from the affected side. Unfortunately, although intraoperative recognition of ureteric injury has been described, the diagnosis is frequently delayed until some time following the procedure. Thermal injury will present 24 hours to 14 days following surgery with one or a combination of fever, abdominal or flank pain, and the clinical findings of peritonitis. A leukocytosis may be present and an intravenous pyelogram will demonstrate extravasation of urine or a urinoma. Not surprisingly, cases of laparoscopy-associated ureteric obstruction seem to present at a time similar to those that follow laparotomy-based procedures - a few days to a week following the operation, usually with flank pain and fever. The diagnosis may be suggested by abdominal ultrasound, but intravenous pyleogram can be more precise at identifying the site and degree of the obstruction.

Uretero- or vesicovaginal fistula will present in a delayed fashion with urinary incontinence or vaginal discharge. Confirmation of bladder fistula will be by direct visualization and/or the leakage of instilled methylene blue onto a tampon. Ureterovaginal fistula will not pass the methylene blue from the bladder but will be demonstrated with the intravenous injection of indigo carmine.

Risk Reduction

Trocar-related cystotomies are generally preventable with routine preoperative bladder drainage. Additional caution must be exercised in the patient previously exposed to abdominal or pelvic surgery, where there is a tendency for scarring and retraction to pull the bladder above the level of the symphysis pubis. The urachus, although rarely patent, should be avoided if possible. It is likely that the placement of an indwelling catheter, at least for prolonged or difficult cases, will reduce the incidence of injury resulting from dissection. Sharp mechanical dissection is preferred, particularly when relatively dense adhesions are present.

A requisite to risk reduction is knowledge of the ureter's anatomy as it courses through the pelvis. It is essential to understand the proximity of the ureter to the uterine artery, the cervix and the uterosacral ligaments, and that any of these relationships may be distorted by previous surgical dissection or by disease such as endometriosis or leiomyomas. If the surgeon cannot, with assurance, steer a wide path from its course, the ureter must be directly visualized, especially when laser, electrosurgical or stapling techniques are employed. Frequently, the ureter can be seen through the peritoneum of the pelvic sidewall between the pelvic brim and the attachment of the broad ligament. However, even in this location, the location of the ureter can be obscure because of anatomical variation, or the presence of pathology, situations that mandate dissection of the retroperitoneal space.

Entry into the retroperitoneal space is accomplished at a location near the site of planned dissection where the location of the ureter is known or anticipated. If the ureter is seen through the peritoneum, it may be grasped with a Babcock forceps to minimize trauma while the peritoneum is incised. If the ureter cannot be seen through the peritoneal surface, a fine, toothed forceps should be employed to grasp and elevate the peritoneum allowing careful entry into the retroperitoneal space with scissors. Careful sharp and blunt dissection then may be applied to exposure the ureter in the operative field.

The techniques employed for retroperitoneal dissection are also important in reducing the risk of ureteric injury. Some instill fluid into the retroperitoneal space under pressure while others advocate the selective preoperative placement of illuminated ureteric
stents. The author prefers the use of mechanical (sharp or blunt) dissection with sharp curved scissors and a narrow, curved, articulated, bipolar grasping forceps attached to an electrosurgical generator. Dissection is undertaken respecting the blood supply of the ureter by minimizing direct manipulation and by preserving the integrity of its sheath. If electrical energy is used, it must be applied judiciously, at safe distances from the ureter and its blood supply. The narrow bipolar grasping forceps facilitates precise and safe desiccation of small caliber blood vessels.

**Treatment**

Small caliber injuries to the bladder (1-2 millimeters) will heal spontaneously with prolonged catheterization for one to two weeks. However, the duration of such catheterization can be reduced or the need eliminated if repair is undertaken intraoperatively. When a more significant injury to the bladder is identified, it can usually be repaired under laparoscopic direction, provided the presence of adequate surgical skill and a location that is amenable to laparoscopic technique. Further evaluation of the location and extent of the laceration may be provided by direct laparo-cystoscopic examination of the bladder lumen using a small-caliber endoscope (1.5 - 2 mm diameter). Should the laceration be near to or involve the trigone, open repair may be preferable. In making this evaluation, the mechanism of injury should be considered, as desiccation resulting from electrical energy may extend beyond the visible limits of the lesion.

For relatively small lesions, a single layer, simple or pursestring closure may be fashioned using any of a number of synthetic absorbable sutures of 2-0 to 3-0 caliber, tying the knot either intra or extracorporeally. For linear lacerations, the defect is preferably closed in two layers. If there is significant thermal injury, it may be valuable to excise the area felt to be damaged prior to repair. Post-operative catheterization with either a large caliber urethral or suprapubic catheter should be maintained for 5-7 days for simple fundal lacerations, and for two weeks for those closer to the trigone, the vaginal vault or those that may be associated with significant thermal injury.

Intraoperative diagnosis of ureteric injury provides the opportunity for intraoperative management. Very limited damage may respond adequately to the passage of a ureteric stent for about 10 to 20 days. In most instances, however, repair is indicated following the surgical principles previously established for open cases. While laparoscopically-directed repair of ureteric lacerations and transections has been described, such maneuvers should be practiced only by those with exceptional surgical skill and experience. Even in these cases it is advisable to consult intraoperatively with a specialist in urology.

When the diagnosis of obstructive ureteral injury is delayed until following surgery, the first imperative is to establish drainage. Some obstructions or lacerations, if incomplete or small, may be successfully treated with either the retrograde or anterograde passage of a ureteral stent. Urinomas may be drained percutaneously. If a stent cannot be successfully manipulated across the lesion, a percutaneous nephrostomy should be created and plans should be made for operative repair.

**NEUROLOGIC INJURY**

Peripheral neurologic injury is usually related either to inappropriate positioning of the patient or to pressure exerted by the surgeon or assistants. Nerves may also be injured as a result of the surgical dissection.

In gynecologic procedures, the legs are usually held in stirrups and flexed at the knee while the hips are abducted, flexed and externally rotated. Such a position predisposes to peripheral nerve injury in the lower extremity from direct trauma, such as compression of the
Munro Complications of Gynecological Laparoscopy

peroneal nerve against stirrups, or stretch injuries of the femoral nerve or the sciatic nerve or its branches from inappropriate positioning of the hip or the knee joint.

Because gynecologic procedures require exposure of the pelvis, the use of Trendelenberg's position is necessary. In such instances the brachial plexus may be damaged because of the pressure exerted on the shoulder joint. Brachial plexus injuries may also occur secondary to the surgeon or assistants leaning against the abducted arm during the procedure.

Recognition

In most instances, the patient is found to have sensory and/or motor deficits as she emerges from the effects of the anesthesia. The diagnosis can usually be suspected by clinical examination. Injuries to the peroneal nerve will be reflected by loss of sensation in the lateral aspect of the leg and foot together with the observation of a foot drop. Brachial plexus injuries may be variable, but usually involve damage to the C-5,6 roots manifesting in loss of flexion of the elbow, and adduction of the shoulder. Electromyography can be used to further define the extent and location of the lesion(s) by testing nerve conduction and recording the electrical potential for various muscles. This evaluation should be delayed for three weeks to allow for complete degeneration of injured nerves.

Risk Reduction

The incidence of brachial plexus injury can be reduced by placing the arms in an adducted position, which facilitates the performance of pelvic surgery and prevents the surgeon from leaning on the patient's arm. Should it be necessary to leave the arm in an abducted position, adequate padding and support of both arms and shoulders is necessary. Also helpful is the use of shoulder supports, that prevent slippage of the patient up the table when placed in the Trendelenburg position.

Sciatic and peroneal nerve injury is best prevented with the use of appropriate stirrups and careful positioning protocols. Those stirrups that combine both knee and foot support are probably best. Additional measures include simultaneous raising and lowering of the legs, flexion of the knees before flexion of the hips, and limitation of external rotation of the hip. Assistants should be admonished to avoid placing undue pressure on the inner thighs.

Injury to the obturator and genitofemoral nerves is uncommon but will likely increase as greater numbers of retroperitoneal dissections are performed. In such cases, it will be important to clearly understand the anatomy, maintain hemostasis and to exert the utmost care in performing the dissections, carefully identifying the neural structures as they are encountered.

Management

Most injuries to peripheral nerves recover spontaneously. The time to recovery depends upon the site and severity of the lesion. For most peripheral injuries full sensory-neural recovery occurs in three to six months. Recovery may be facilitated with physical therapy, appropriate braces and electrical stimulation of the affected muscles. Transection of major intrapelvic nerves will require open microsurgical repair.

INCISIONAL HERNIA and WOUND DEHISCENCE

While the incidence of gynecologic laparoscopy-associated incisional hernia is unknown, it is clear that the complication has been underreported. And, although the first case was described by a gastroenterologist in 1967, few such hernias had been reported in the gynecologic literature until 1994, when a survey of a large number of gynecologists uncovered
Complications of Gynecological Laparoscopy

Over 900 laparoscopy associated defects. Further reports of incisional hernia have emanated from the urologic and general surgical literature as cholecystectomy and other procedures undergo conversion to laparoscopic technique. These and other reports seem to indicate that while no incision is immune to the risk of herniation, those defects that are 10 millimeters or more in diameter are particularly vulnerable. Another important factor contributing to risk may be the use of cannula anchoring devices that effectively increase the diameter of the incision by up to three millimeters.

One source of confusion in the literature is the lack of distinction among the terms evisceration, wound dehiscence and true hernia, nomenclature that seems to be used interchangeably. Indeed, the distinction may be rather moot as dehiscence of a laparoscopic wound may be irrelevant unless bowel or other intraperitoneal tissue herniates into and through the defect. One of the more sinister complications, involving only a portion of the bowel wall, is Richter's hernia, which is somewhat more difficult to diagnose and may result in perforation, peritonitis and death.

Diagnosis

The most common defect appears in the immediate post operative period where bowel or omentum passes through the unopposed or inadequately repaired incision. The patient may be asymptomatic or can present with any or a combination of pain, fever, periumbilical mass, obvious evisceration and the symptoms and signs of mechanical bowel obstruction, often within hours and usually within the first post operative week. Because the patients are usually discharged home shortly after surgery, the symptoms and signs usually manifest out of hospital with the presentation taking place by telephone. Consequently, the surgeon should take care not to casually disregard the patient who telephones with symptoms consistent with herniation.

Because Richter's hernia's contain only a portion of the circumference of the bowel wall in the defect, the diagnosis is often delayed. It is likely that such lesions most commonly occur in incisions that are made away from the midline. The initial presenting symptom is usually pain, since the incomplete obstruction still allows the passage of intestinal content. Fever can present if incarceration occurs, and peritonitis may result from the subsequent perforation. The diagnosis is difficult to make and requires a high index of suspicion. Ultrasound or CT scanning may be useful in confirming the diagnosis.

While many defects likely remain asymptomatic, late presentation may occur if bowel or omentum becomes trapped. The symptoms and findings are similar to that described for earlier presentations.

Risk Reduction

It is desirable to use the smallest diameter cannulas whenever possible, recognizing that hernia has even been reported in conjunction with the use of 5 millimeter trocars. The "Z-track" insertion method offsets skin and fascial incisions, potentially reducing the incidence of hernia. The subcutaneous tissue is entered with a conically tipped trocar which is then slid along the fascia for a short distance prior to penetrating it. A third approach is to remove all ancillary cannulas under direct vision to ensure that bowel is not drawn into the incision. Insertion of an obturator (or a laparoscope) into the cannula may further prevent suction from drawing bowel or omentum into the incision. Finally at least those incisions 10 millimeters or greater in diameter should undergo fascial closure under laparoscopic direction, thereby preventing incorporation of bowel. This may be accomplished by using a 5 millimeter or smaller diameter laparoscope through one of the smaller cannulas. A narrow diameter, three
Complications of Gynecological Laparoscopy

quarter round, needle (Ethicon UR-6; Davis & Geck TT-20; US Surgical GU-46) facilitates closure, as does the use of a laparoscopic ligature carrier.

If the final incision is of sufficiently large diameter to require closure, blind insertion of needles may be avoided by prepositioning sutures. They are placed at the time of entry for open laparoscopy or when the laparoscope is in an another location. In each instance, the sutures are tied following removal of the final cannula. The sutures should be used to elevate the abdominal wall as the laparoscope and cannula are simultaneously removed, looking down the endoscope to ensure that bowel or omentum are not inadvertently drawn into the wound.

Management

Management of laparoscopic incisional defects depends upon the timing of the presentation and the presence or absence of entrapped bowel and its condition. Evisceration will always require surgical intervention. If the diagnosis is made in the recovery room, the patient may be returned to the operating room, the bowel or omentum replaced in the peritoneal cavity (provided there is no evidence of necrosis or suture incorporation), and the incision repaired, usually under laparoscopic guidance. However, if the diagnosis is delayed it is likely that the bowel is incarcerated and at risk for perforation. In such circumstances, resection will likely be necessary, usually via laparotomy. Most gynecologic surgeons should request general surgical consultation.

INFECTION

Wound infection following gynecologic laparoscopy is rarely reported, making the incidence difficult to estimate. While the vast majority of wound infections are handled successfully with expectant management, drainage or antibiotics, severe necrotizing fascitis has been reported.

Other types of post laparoscopy infection have been reported including bladder infection, pelvic cellulitis and pelvic abscess. While bacteremia has been described, there have been no reports of disseminated infection following laparoscopic surgery. In summary it seems that the risk of infection associated with laparoscopy is low; much lower than that associated with open abdominal or vaginal surgery. Nevertheless, until clinical studies dictate otherwise, it is prudent to continue to practice strict sterile technique and to offer appropriate prophylactic antibiotics to selected patients. These could include those with enhanced risk for bacterial endocarditis as well as those who are to undergo procedures (eg. laparoscopic hysterectomy) suspected of increasing the chance of wound or vault infection. Patients should be instructed to routinely take their temperature following discharge and to immediately report fever of 38°C or greater to their surgeon.

PROCEDURE-SPECIFIC COMPLICATIONS

Some or all of the complications discussed above may be associated with any gynecologic procedure performed under laparoscopic direction. However, some complications have a predilection to a specific type of procedure. In this section the issue of delayed complications will be addressed, particularly with respect to the impact of laparoscopic surgery on future fertility.

ADNEXAL SURGERY
Adnexal surgery includes procedures performed on the fallopian tubes or the ovaries. Removal of ectopic gestation, reconstructive surgery for infertility and the removal of ovarian or other adnexal masses comprise the majority of the operations encountered. The more common intraoperative complications include hemorrhage and damage to the ureter, while delayed complications more likely involve compromise of future reproductive function.

Ectopic Gestation

Ectopic gestation most commonly involves the isthmus or ampulla of the fallopian tube, and may be removed via salpingectomy, or, if the oviduct is to be conserved, by segmental resection or salpingotomy. It is unusual for any of these procedures to be associated with visceral injury. However, salpingectomy can be associated with hemorrhage, mandating adequate application of occlusive techniques. I would suggest liberal use of electrosurgical coagulation for the vascular pedicles. At salpingotomy, intraoperative or post operative hemorrhage is possible from the vascularized ectopic "bed". Most gynecologists use dilute vasopressin injected between the leaves of the mesosalpinx to effectively eliminate the risk of bleeding. However, there are some systemic complications associated with the use of vasopressin, including cardiorespiratory collapse and death, if it is injected into the systemic circulation. Consequently, the solution used should be dilute (20 Units vasopressin in 60 to 100 cc of normal saline) and extreme care should be used in avoiding intravascular injection. The preferred site is between the leaves of the mesosalpinx, well away from the oviduct, where the engorged vessels are more vulnerable to needle entry.

Reconstructive Surgery

The most commonly performed reconstructive procedures are those aimed at the distal end of the oviduct, obstructed or distorted with adhesions from previous pelvic inflammation. Because of the anatomic location of the dissection, damage to the bowel or urinary tract is uncommon, unless the adhesive process has significantly involved those organs. In such instances, post operative reproductive outcome is generally so poor that visceral trauma is prevented by resorting to a more effective assisted reproductive procedure such as in vitro fertilization (IVF) and embryo transfer (ET).

The common intraoperative complications are hemorrhage and trauma to the oviduct. The incidence of both of these complications is minimized with the use of appropriate instruments and by patient and careful attention to technique.

The video image must be focused and of sufficient resolution to allow the surgeon to distinguish the vascular anatomy. A good suction and irrigation system will help with location of severed blood vessels. For pelvic reconstruction I often have available a non-conductive fluid like glycine which facilitates electrosurgical desiccation of small vessels, even when direct contact is not made. However, extreme care must be exercised to avoid excessive use of hypotonic solutions because the potential for fluid and electrolyte imbalances. The addition of 5000 IU of heparin to each liter of irrigation solution largely prevents the formation of clots, facilitating removal of blood from the peritoneal cavity.

Sharp, fine scissors and minimally traumatic traction and countertraction are critical for the establishment of tissue dissection planes. Whenever blood vessels are identified they are immediately occluded, usually electrosurgically, with a fine-tipped uni- or bipolar grasping forceps. The fine tips minimize the amount of energy required for occlusion of the vessels, thereby reducing local thermal trauma. We use both toothed and non toothed forceps for, in some instances, the former may ultimately be less traumatic because of the ability to firmly hold tissue with only a very small purchase. Modified Babcock forceps minimize trauma
Complications of Gynecological Laparoscopy

to the ciliated tubal epithelium and are useful when it is necessary to hold a substantial part of the oviduct for exposure or traction.

Any surgery in the reproductive tract can result in adhesions that could impair fertility. It is widely held that the optimal prophylactic approach to adhesion formation is by adhering to principles of microsurgery that include: (1) Minimization of tissue trauma, (2) Meticulous hemostasis, (3) Excision of clearly abnormal tissue, (4) Precise alignment of tissue planes, (5) Minimization of foreign body material such as lint and suture, and (6) Magnification which permits the appreciation of normal and abnormal tissue and enables the use of small-caliber suture. The lens system of the laparoscope affords an adequate degree of magnification. While a number of agents have been touted as adjuvants helpful for reducing post-operative surgical adhesions in the oviduct, none have been demonstrated to improve post operative fertility compared to the other or to no treatment at all. Several intraperitoneal fluids have been used including normal saline and heparinized Ringer's lactate. However 200cc of intraperitoneal 32% Dextran 70 (Hyskon) is the only available liquid substance that has been shown, but only in some studies, to reduce the incidence of adhesions. Absorbable barriers or non-absorbable membranes have clearly been shown to reduce the incidence of adhesions in a majority of the reported comparative studies. However, there are stringent criteria for the use of these substances. The operative field to be covered must be totally free of bleeding and, non-absorbable membranes cannot be used around the ovary for they would prevent conception and ovum pickup.

Oophorectomy and Ovarian Cystectomy

Ovarian masses can be removed by oophorectomy, or by cystectomy, thereby preserving ovarian function. When oophorectomy is performed, the principle complications to consider are hemorrhage and damage to the ureter or other pelvic viscera if they are involved with the mass.

Hemorrhage

Hemorrhage is largely prevented by securing adequate hemostasis, particularly of the ovarian vessels contained within the infundibulopelvic (IP) ligament. There are a number of technical options, including suture, clips, electrosurgical desiccation, and linear stapling devices. While all of these methods can be effective, each has advantages and disadvantages with respect to cost, time and related complications.

Suture is the most time consuming to apply, and has no direct complications associated with its use. However, unless the vessels are adequately skeletonized, bleeding can ensue as the ovarian artery releases and retracts cephalad within the ligament. In such cases the surgeon must dissect the peritoneum cephalad, but just lateral to the IP ligament, resecuring the vessels two to three centimeters above the level of the original transection. Care must be taken to avoid damage to the ureter.

Titanium clips do not securely hold the IP ligament of most women, largely because the diameter of the compressed vessels is larger than the length of the clip. Consequently, we recommend the larger absorbable clips that can occlude vessels more securely. Electrosurgical desiccation may be accomplished with either unipolar or bipolar energy derived from the "cutting" output of the generator. However, care should be taken to both isolate and compress the vessels, prior to desiccation, steps that reduce the amount of
Complications of Gynecological Laparoscopy

energy required, and which largely eliminate the risk of ureteric injury. When bipolar energy is used, a serial ammeter may provide additional evidence of adequate coagulation.

Ureteric Trauma

The ureter can be damaged, either when the IP ligament is secured or in association with dissection of an ovarian mass adherent to the ovarian fossa. Trauma is prevented by ensuring that the ureter is not in the area of dissection, usually by direct visualization.

If the ureter must be visualized directly, we open the peritoneum between the round and IP ligament, extending the incision cephalad further than we would in an open case. This allows sufficient medial retraction of the ovary with to visualize of the ureter following posteromedially directed blunt dissection. A window cut in the sheet of peritoneum between the IP ligament and the ureter will facilitate application of any of the occlusive techniques described above.

If the ovary is adherent to the peritoneum of the ovarian fossa, it is likely overlying the ureter. In such a circumstance, gentle blunt dissection of the ovary from the peritoneum is sometimes successful. Care should be taken to avoid sharp dissection without visualizing the ureter, especially with electrical or laser energy, as lateral extension may cause significant trauma. Consequently, in the presence of cohesive adhesions, the peritoneum should breeched as described above, entering the retroperitoneal space to identify the ureter, before proceeding further with the dissection. Then the ovarian mass can be safely dissected from the pelvic sidewall with the ureter in full view.

Ovarian Masses and Malignancy

Common to both cystectomy and oophorectomy is the impact on prognosis of removing a malignant lesion under laparoscopic guidance. The current practice is to limit laparoscopic oophorectomy to masses likely to be benign based upon pre-operative clinical examination and ultrasonic imaging. The latter is helpful in excluding sonographically complex or solid lesions and by using doppler flow analysis to identify lesions suggestive of malignant neoplasia. If the ultrasonic findings are consistent with a teratoma, most experienced gynecologic laparoscopic surgeons will consider endoscopically-directed removal. Post-menopausal women should additionally have a preoperative measurement of CA-125 which, if elevated, is highly suggestive of malignancy. At laparoscopy, morphologic features may be encountered suggestive of malignancy, which direct the surgeon to pursue laparotomy for adequate staging and cytoreduction of the tumor as well as any identified metastatic lesions. However, the diagnosis of malignancy may not be made intraoperatively until a frozen section of the mass is read, or even post-operatively when the final paraffin sections are made and reported.

Clearly if appropriate staging of ovarian carcinoma is not done, or not immediately completed, the prognosis for the patient may be compromised. However, it is unknown whether or not laparoscopically-directed removal of malignant ovarian masses has any effect on prognosis. Some have argued that spillage of malignant ovarian cyst content changes survival, but the best available studies suggest that such an event has no impact, at least if an immediate and complete staging procedure is performed. For those who remain concerned, the use of a specimen bag to contain the cyst and its aspirated contents, prior to removal from the peritoneal cavity, may eliminate any potential for spilled to compromise prognosis.
Complications of Gynecological Laparoscopy

Uterine Surgery

Virtually all of the abdominal uterine procedures may, in selected instances, be accomplished under laparoscopic direction. Most of the procedure-specific encountered complications are related to the urinary and gastrointestinal tracts.

Myomectomy

Laparoscopically-directed removal of leiomyomas from the uterus is an operation fraught with controversy, largely because of the technical difficulties associated with the procedure and partly because of the potential for complications.

Hemorrhage is the most perilous complication of myomectomy by any route. Such bleeding may be reduced with a number of measures including: (1) Preoperative use of gonadotropin releasing hormone agonists for two to four months, (2) Mechanical compression of the uterine blood supply, and (3) Injection of vasoconstrictive substances in the uterine stroma prior to dissection. Mechanical compression requires isolation of the uterine vessels, a feat often difficult at laparoscopy with the frequent anatomic distortion and limited exposure created by uterine myomas. The most commonly used intraoperative modality is injection of dilute vasopressin (Pitressin 20 units in 60-100cc normal saline) around the operative site, taking care to avoid intravascular injection.

Because myomectomy is almost universally performed on women who wish to preserve or enhance their fertility, the prevention of adhesions is an important issue. Adhesions are likely minimized by following the principles of microsurgery described above for adnexal surgery. In addition, reduction of the number of incisions and confining them to the fundus or anterior wall of the corpus will minimize the chance that the posterolaterally located fallopian tubes and ovaries will adhere to the uterus. Theoretically at least, the placement of an adhesion barrier over the incision(s) will inhibit the adhesive process, potentially enhancing postoperative fertility.

Hysterectomy

Laparoscopic hysterectomy (LH) is actually a spectrum of procedures ranging from endoscopically-directed adhesiolysis followed by vaginal hysterectomy, to total hysterectomy performed under laparoscopic guidance. However, most often, gynecologic surgeons perform a portion of the procedure laparoscopically, completing the removal of the uterus by the vaginal route. As a result, complications associated with LH are associated with three general aspects of the procedure: (1) those associated with laparoscopy in general, such as abdominal wall bleeding or incisional hernia; (2) complications of the laparoscopically dissection; and (3) complications associated with the vaginally directed component of the operation.

Because the variable ratio of laparoscopic to vaginal dissection may significantly affect the nature and extent of complications, a classification system has been described, stratifying the procedure according to the amount of dissection performed under endoscopic guidance (Figure 3, Table 1). Type "0" procedures are limited to those where adhesions are lysed prior to vaginal hysterectomy. The remaining major types are categorized according to the amount of lateral dissection. Type I procedures include the ovarian arteries and veins, Type II operations include one or both uterine arteries and veins, Type III part of the cardinal-uterosacral ligament complex and Type IV, all of the cardinal-uterosacral ligament complex. Subtypes describe bladder dissection (B), the performance of a posterior culdotomy (C), both bladder dissection and culdotomy (D), or removal of the entire uterus (E). Complications associated with laparoscopy in general are discussed earlier in this chapter; those resulting from
the laparoscopically-directed portion of the hysterectomy will now be reviewed according to hysterectomy type.

Some general comments relating to all types of LH are in order. First, it is valuable for these procedures to have an assistant capable of functioning well from the two dimensional environment of the video monitor. Second, a well designed uterine manipulator is critical to success and efficiency; its value cannot be overestimated. Such a manipulator should have an obturator that extends the full length of the endometrial cavity, but which is articulated, allowing at least 90° of anteversion and retroversion. Third, while preoperative single dose, prophylactic antibiotics have been demonstrated effective at reducing febrile morbidity for vaginal hysterectomy, the same has not been proven for LH. However, given the vaginal dissection that comprises a part of most laparoscopic hysterectomies, it seems reasonable to recommend that routine antibiotic prophylaxis be recommended until or unless data surfaces suggesting the contrary. Fourth, the surgeon should be competent at using a variety of occlusive techniques (suturing, clips, electrical energy, stapling), for circumstances will arise that will dictate the use of any or all in a given operation. Finally, the surgeon should only operate laparoscopically until sure that the procedure can be completed vaginally. This not only saves surgical time and cost, but it likely reduces complications as well. However, it is important to prudently determine those cases that must be completed abdominally - pressing the laparoscopic dissection in difficult circumstances will only court disaster.

Type 0

Type 0 procedures involve lysis of adhesions prior to performance of a vaginal hysterectomy. However, because these adhesions often involve large and small bowel, gastrointestinal injury is the most common complication of the laparoscopic dissection. A relatively common site of trauma is the sigmoid colon when it is bound by adhesions to the posterior aspect of the cervix and corpus. The risk of bowel entry can be reduced by minimizing the use of electrical or laser energy, and by dissecting with one finger of the surgeon's non-dominant hand in the vagina and one in the rectum, providing orientation and retraction. The dissection should be initiated and continued in a fashion more liable to leave uterine serosa on the bowel rather than bowel mucosa on the uterus.

Type I

Type I laparoscopic hysterectomy includes occlusion and division of the round ligament and of the ovarian vessels either medial or lateral to the ovaries, depending upon the need for oophorectomy. Consequently, the additional complications are usually either hemorrhagic or damage to the ureter near its course over the pelvic brim or along the ovarian fossa.

Hemorrhage is prevented by properly applying the techniques described elsewhere in this chapter. At the inferior border of the round ligament is Sampson's artery, a vessel that will easily bleed if care is not taken to occlude it. I would suggest either bipolar or unipolar electrosurgical coagulation for this pedicle. For the utero-ovarian pedicle, taken when the ovary is conserved, either electrosurgical coagulation or the use of a linear cutting and stapling device are the two most effective and efficient methods. I use either large absorbable clips or electrosurgical coagulation for the infundibulopelvic ligaments, divided when oophorectomy is performed.

Ureteric injury in Type I hysterectomy is limited to those procedures where oophorectomy is performed, particularly when the ovary is adherent to the ovarian fossa. The
key to prevention of ureteric injury is visualization of the ureter prior to application of an occlusive technique, if necessary, following retroperitoneal dissection.

**Type II**

Type II procedures are distinguished from Type I operations by virtue of ligation and division of the uterine blood vessels. Extension of the lateral dissection to include occlusion and division of the uterine vessels adds the potential for new hemorrhagic and ureteric complications. The technique involved in this aspect of the procedure varies, depending upon where in the course of the uterine artery the vessels are occluded. Near its origin from the internal iliac artery the uterine artery, together with the vein are predictable in their location and in their relationship to the ureter, which occupies a course just medial and inferior to the uterine vessels. However, as the artery courses medially, toward the uterus, it bifurcates into an anterior and a descending branch; the anatomy of the veins varies extensively.

Perhaps the most commonly-reported and encountered ureteric complication is obstruction caused by a linear cutting/stapling device used without prior, adequate visual identification of the ureter. Ureteric injury is also possible from suture or from extension of tissue coagulation from electrosurgical energy. In addition, extensive dissection of the ureter may damage its sheath and the local blood supply leading to a urinoma or fistula.

When it is anticipated that a Type II (or greater) procedure is to be performed, and before the commencement of any other dissection, I use a small parallel peritoneal incision to mark the most distal location of the ureter as seen through the peritoneum. Usually this site is within two centimeters of the uterine artery and vein, near their origin from the internal iliac vessels. If the uterine vessels are to be taken laparoscopically, this incision is extended caudad, and blunt dissection performed until the ureter is seen running under the uterine artery. I then isolate the artery and vein, and use one or a combination of clips, bipolar electricity and suture ligature to occlude the artery and vein, medial to the ureter, thereby preserving its local blood supply. The vessels are then divided with scissors.

The approach described above also ensures that the uterine vessels are occluded in toto. When instead such dissection takes place near to the uterus it is common to miss the descending branch of the uterine artery. Sometimes this omission could lead to bleeding later in the dissection, particularly when the approach shifts to the vaginal venue. In such instances, the descending branch is more likely to tear during vaginal manipulation because there is little protective support from the broad ligament largely dissected in the laparoscopic aspect of the procedure.

**Type III-IV**

Types III and IV operations include lateral dissection below the uterine vessels involving part or all of the cardinal-uterosacral ligament complex respectively. Hemorrhage is a potential problem, but ureteric injury is the complication that causes most gynecologic surgeons to avoid these types of operations. The ureter may come as close as 9mm from the lateral edge of the normal cervix - no laparoscopic technique has been demonstrated to be as safe as the ureter-preserving, tight clamping of the cardinal ligaments that is used in abdominal and vaginal surgery. This is unfortunate, for laparoscopically directed occlusion and division of these ligaments provides much of the promise for LH, for the conversion of abdominal hysterectomy to a less morbid approach.

Avoidance of ureteric injury in Type III and IV procedures requires that the ureter be exposed sufficient to ensure that it is not damaged by the paracervical dissection. This requires unroofing of the ureteric tunnel, using a combination of sharp and blunt dissection with
Complications of Gynecological Laparoscopy

Hemostasis provided by clips and/or limited and judiciously applied electrosurgical energy. The simultaneous hemostasis and cutting provided by ultrasonic ligating cutting shears may be particularly applicable for Type III and IV procedures, potentially obviating the need for ureteric dissection. However, extreme care must be exercised when using this technique, ensuring that the shears slide off the cervix, remaining closely applied to its lateral border prior to activating the device. This approach will not be appropriate for the expanded cervix that extends closer to the course of the ureter.

Subtype B

Any laparoscopic hysterectomy that includes dissection of the bladder from the corpus and/or cervix is subtyped as "xB". It is during this phase of the laparoscopic aspect of procedure that unintentional cystotomy usually occurs. Such a complication is more likely in women with endometriosis over the bladder peritoneum or in those who have undergone previous surgical dissection of the vesicouterine junction, usually during the course of a Cesarean section. Prevention of injury requires that scissors be used for sharp and blunt dissection. If peritoneal scarring inhibits establishment of the appropriate plane centrally, it may often be found by approaching the dissection laterally. Blunt dissection of the bladder with a sponge is acceptable for the non-adherent bladder, but fraught with the potential for vesicle laceration when performed in the face of adhesions.

When the bladder is completely dissected from the uterine cervix, it is possible to enter the vagina under laparoscopic direction. Care must be taken to ensure that the bladder is additionally dissected from the superior vagina adequate to allow entry without visceral injury. The incision is fashioned over a moist sponge inserted into the anterior cul-de-sac with a ratcheted ring forceps. The suggested modality is monopolar electrosurgical energy applied with closed scissors, but laser or ultrasonic energy are equally effective at reducing the chance of vaginal cuff bleeding.

Subtype C

Subtype C operations include any type (I-IV) where a posterior culdotomy is performed under laparoscopic direction. The complications associated with this procedure seem confined to damage to the rectum or sigmoid colon. Avoidance of this injury complicating dissection of the obliterated cul-de-sac is described under "Type 0" above. When actually creating the culdotomy, electrosurgical, laser or ultrasonic energy is preferred because each reduces the incidence of vaginal cuff bleeding. The incision is fashioned between the uterosacral ligaments over a moistened sponge on a ring forceps placed into the posterior vaginal fornix and elevated cephalad by an assistant. Care must be taken to ensure that the sponge is placed in the vagina and not the rectum, as it is difficult to make this distinction laparoscopically. Furthermore, the surgeon must ensure that the incision stays between the uterosacral ligaments, thereby preventing ureteric injury.

Subtype D and E

Any laparoscopic hysterectomy type that include the variable bladder dissection of subtype B operations and the posterior culdotomy of "C" procedures are denoted as Subtype D. Consequently, the potential complications reflect the additional risks of each aspect of the dissection. Subtype E operations add some risk to the ureters, but the precautions are essentially only an extension of those for all Type III and IV procedures.

Vaginal Dissection
Munro  Complications of Gynecological Laparoscopy

The vaginal dissection that comprises a portion of all but Type IV E procedures may as well be a source of complications. Hemorrhage, bladder, ureter and bowel injury may all occur during or as a result of the vaginal component of the procedure, but will not be dwelt upon here.

Surgery for Peritoneal Endometriosis

Endometriosis is an enigmatic disorder characterized by the existence of endometrial glands and stroma outside of the uterine cavity and myometrium. The extent of the process varies extensively, both with respect to the volume of ectopic endometrium and its involvement of peritoneal surfaces and underlying viscera. In addition, there is great variation in the amount of inflammatory response, ranging from none to the development of extensive cohesive adhesions that obliterate dissection planes, binding abdominal-pelvic viscera to each other or to other peritonealized surfaces.

The management of adhesions that obliterate the cul-de-sac or that bind the adnexa has been discussed above in the sections on adnexal masses and Type "0" laparoscopic hysterectomy. The surgeon performing laparoscopically-directed treatment of peritoneal endometriosis must consider the depth of the disease as well as the underlying structures applying a specific technique. A frequently used approach is vaporization with the CO₂ laser. Complications of this approach include hemorrhage as well as ureteric, bladder and bowel injury, usually related to penetration of the vaporization process beyond the base of the lesion. The surgeon has a number of options for the reduction of these complications. One approach is to avoid laser energy entirely or at least in lesions that are near to or overlying areas of endometriosis. Alternatively using a needle can be used to instill fluid underneath the lesion which would buffer the effects of the laser energy. If laser energy is not used, scissors may be employed to excise the lesions or, electrosurgery can be utilized either as a cutting modality or to coagulate the endometriosis tissue.

Adhesions may complicate the vaporization or excision of endometriotic lesions. The substances and materials described above in the section on adnexal reconstructive surgery may be employed.
17. Childers JM, Brzechta PR, Surwit EA. Laparoscopy using the left upper quadrant as the primary trocar site. Gynecol Oncol 1993;50:221-5.
Munro Complications of Gynecological Laparoscopy


LAPAROSCOPIC COMPLICATIONS:
STRATEGIES TO AVOID THEM

Goals of Video Presentation (2001)

1. To Identify Surgical Problems Encountered by Obstetricians/Gynecologists
2. To Discuss Strategies to Avoid, to Recognize, and to Lessen the Impact of Complications.

ROBERT B. HUNT, M.D.
319 LONGWOOD AVENUE
BOSTON, MA 02115
E-MAIL: rbhunt100@earthlink.net
FAX: 508-785-0178
Hunt Laparoscopic Complications: Strategies to Avoid Them

INTRODUCTION

To survive relatively intact today, the ob/gyn must have a profound sense of situational awareness. This brief presentation addresses problems encountered by the ob/gyn performing laparoscopy, but is also applicable to all ob/gyns, regardless of focus. I share with you my thoughts on ways to reduce the risks, to recognize complications, and to lessen morbidity.

CREDENTIALING

Make certain that you are properly credentialed for the procedures that you perform. Credentialing is a local issue, not a national one. In other words, accreditation by a society, such as AAGL, does not take the place of credentialing. You should update the list of what you are credentialed to do with your department chief at least each year.

INFORMED CONSENT

Briefly, informed consent is a process. It is not just that piece of paper provided by the hospital signed by the patient at the time of surgery. It is important to document as best you can shared with the patient and a summary of topics discussed with the patient in determining whether to proceed with surgery. It is essential to have the patient be a part of the decision making process.

PATIENT SELECTION

Surgeons sometimes get into trouble as a result of selecting the incorrect operation for the patient. Laparoscopy is just a method of access. We must resist the temptation of wedding ourselves to a particular access for a particular problem. For example, if the surgeon is unduly concerned about the risk of bowel injury, another access should be considered. Also, the procedure should be terminated or a switch to an alternate procedure if the surgeon is confronted with problems that outstrip the technique being used.

INTRAABONIMAL ACCESS

At least half of substantial laparoscopic complications are related to gaining access. Please consider the following suggestions.

A. Be trained in more than one technique, such as closed, open, and left upper quadrant entry.
B. Consider left upper quadrant entry if periumbilical adhesions or umbilical hernia is suspected.

C. Prior to inserting primary and secondary cannulas, make certain that abdominal skin incision is adequate for the cannula. Sometimes the cannula “hangs up” on skin, causing a depression of the abdominal wall, placing intraabdominal and retroperitoneal structures at increased risk.

D. Visualize inferior epigastric vessels transperitoneally; use transillumination for more superficial vessels. Then avoid them.

GREAT VESSEL INJURY

Among our deadliest injuries have been to great vessels. Although some of these injuries are avoidable, many can be prevented. The following are a few suggestions to consider.

A. If closed technique with pneumoperitoneum is chosen, inflate the abdomen to approximately 20 to 25 mm Hg pressure initially. This lifts abdominal wall approximately 5 cm further away from great vessels in the posterior retroperitoneal area and provides a much firmer abdominal wall through which to pass the primary trocar-cannula. When intraabdominal placement has been confirmed with the laparoscope, reduce pneumoperitoneum to normal working pressures, usually 11 mm Hg in women of normal build, 15 mm in the heavy woman.

B. Be careful to make certain that the operating table is relatively horizontal with the floor prior to beginning to procedure. It is difficult to determine how much Trendelenburg position the draped patient is in. The problem with steep Trendelenburg position is that great vessels may be placed in harms way, as they are displaced anteriorly, making it difficult for the surgeon to make correct adjustments in insertion angle. Also, the umbilicus is shifted more cephalad, further narrowing the window of safety.

C. When inserting the primary trocar-cannula transumbilically, make absolutely certain that you have it aligned in the midline, and do not allow the trocar-cannula to be diverted off the predetermined trajectory.
Hunt Laparoscopic Complications: Strategies to Avoid Them

D. The best angle of insertion remains controversial. Some advocate a 90° angle, others 45°. The important point to remember is to position the patient properly and to conceptualize where great vessels are located. Then avoid them.

BOWEL INJURY

Eventually, you will inflict injury to the bowel if you do enough laparoscopic procedures. This can happen in the best of hands. However, I offer a few thoughts to reduce risk and to mitigate their consequences.

A. Select your patient carefully.

B. Consider having your patient undergo mechanical bowel preparation prior to the operation. This has many positive results, such as: reduces the space taken up by bowel, particularly large bowel; avoids confusion of trying to determine if a nodule noted in bowel is a lesion (endometriosis) or stool; if perforation of large bowel occurs, and the injury is detected at time of surgery, primary repair may be undertaken with a little less worry about infection.

C. Insert orogastric tube prior to the procedure. This should reduce change of stomach injury and clears left upper quadrant as a potential site of entry.

D. Be careful in use of electrosurgery near bowel, for monopolar energy may find its way full thickness through bowel wall by aberrant pathways. Bipolar energy can cause necrosis by lateral thermal spread.

E. Know where rectum is located. The position is retroperitoneal and can be quite variable.

URETERAL INJURY

Ureters have been perceived as the bane of existence for the ob/gyn. I believe this reputation is not deserved, for ureter is a wonderful structure, and usually a very resilient one—as long as it is not devitalized, cut, or traumatized. The following are worth considering.
Hunt Laparoscopic Complications: Strategies to Avoid Them

A. When dividing infundibulopelvic ligament (IP) as in salpingo-oophorectomy, be careful to identify ureter and open a space between IP ligament and ureter before dividing ligament. All too often ureter is included with IP ligament and traumatized, divided, or devitalized in the process.

When working in the area of uterosacral ligament, identify ureter. An excellent strategy is to incise peritoneum between uterosacral ligament and ureter and reflect ureter laterally. Injury at level of cardinal ligament and uterine vessels is relatively common. When performing laparoscopic hysterectomy, I either select supracervical hysterectomy or secure uterine arteries during the vaginal component should laparoscopic-assisted hysterectomy be chosen. It is my belief that these choices may reduce risk of ureteral injury. If one is concerned that ureter has been injured, consider cystoscopy approximately 10 minutes after intravenous administration of indigo carmine. One should see indigo carmine being ejected from ureteral orifices inside the bladder. Also, ureters can be inspected for leaks at the same time laparoscopically.

BLADDER INJURY

Urinary bladder is a very forgiving organ; however, it too has become a site of laparoscopic injury. The following are thoughts to consider.

A. Insert Foley catheter prior to beginning each procedure. Cap the catheter with catheter plug, which will provide access for repeated drainage or distention during the operative procedure.

B. Visualize bladder margins prior to insertion of secondary cannulas. Distention of urinary bladder may be necessary to accomplish this. Also, it is often helpful to insert the suprapubic trocar-cannula, if used slightly to one side of bladder dome.

C. When using suprapubic cannula, consider placing skin incision slightly superior to prior low transverse abdominal incision (Pfannenstiel), for bladder may be drawn into or close to the prior incision. Also, downward pressure on trocar-cannula at time of insertion can avulse a portion of bladder wall in this scarred area.

D. If air exits through Foley catheter, check carefully for unintended cystotomy.
Hunt Laparoscopic Complications: Strategies to Avoid Them

E. At conclusion of the procedure, check for hematuria. Although hematuria can be caused by catheter trauma, it may also be a sign of ureteral or bladder injury.

HERINA FORMATION

Hernias through access sites have been a recurring problem. Although hernias do occur in the midline and do occur at 5-mm cannula sites, a relatively common problem is the laterally placed cannula 10 mm or larger. I prefer bulk closure (including peritoneum) in these incisions. A serious risk, in part because it is difficult to diagnose, is the Richter hernia. The CT scan should be diagnostic when Richter hernia is suspected.

POSTOPERATIVE CARE

Sometimes complications are not detected or have not developed at the conclusion of the operation. Therefore, it is very important to listen to your patient if she contacts you after surgery. An excellent strategy is to have the patient call you, or you contact her, a day or so after discharge. Laparoscopic patients generally only improve during the several hours or days after surgery. Laparoscopic complications can be very difficult to diagnose, and are often not recognized by medical personnel unaccustomed to seeing these patients postoperatively. Timely diagnosis and proper treatment may ward off Adult Respiratory Distress Syndrome, which may carry a 50% mortality rate, or other serious sequelae. So, if your patient seems to have a worsening situation or is not improving, see her or have her seen as soon as feasible. A high index of suspicion can be life saving.

FINAL THOUGHTS

Complications happen, even in the very best of hands. None of us are immune to complications. The foregoing are strategies that I currently follow, based on 31 years of laparoscopic experience and based on complications suffered by others’ and my own patients. I realize that many suggestions remain controversial, and well respected colleagues will disagree with many of them. However, I hope that you will consider incorporating at least some of these strategies in your practice. I want you to have a long, successful, and happy career in gynecologic surgery.
Hunt Laparoscopic Complications: Strategies to Avoid Them

BOWEL PREPARATION (ONE DAY)

1. Purchase one Fleet enema and one bottle of Magnesium citrate from your pharmacy.

2. The day before surgery:
   Drink ½ bottle of Magnesium citrate in the morning and ½ bottle in the afternoon.
   Breakfast—Light breakfast (for example cereal, cream of wheat, juice, coffee.)
   Lunch—Just liquids (such as custards, jello, soup, cream of wheat, oat meal.)
   Dinner—Just clear liquids (examples include apple juice, bouillon, tea, ginger ale, coffee.)
   Administer a Fleet enema to yourself 1 hour before bedtime.

Call if any questions!
1. Purchase one Fleet enema and two bottles of Magnesium citrate, and two 8 ounce cans of Ensure Plus from your pharmacy.

2. Two days before surgery:
   Drink ½ bottle of Magnesium citrate in the morning.
   Breakfast—Light breakfast (for example cereal, cream of wheat, juice, coffee.)
   Lunch—Just liquids (such as custards, jello, soup, cream of wheat, oat meal.)
   Dinner—Just clear liquids (examples include apple juice, bouillon, tea, ginger ale, coffee.)

3. The day before surgery:
   Drink ½ bottle of Magnesium citrate in the morning and ½ bottle in the afternoon.
   Clear liquids for each meal. Avoid milk products.
   Take one can of Ensure Plus with lunch and another with dinner.
   Administer a Fleet enema to yourself 1 hour before bedtime.
   Nothing by mouth after midnight.

Call if any questions!
PART III

TECHNICAL ASSESSMENT
Endometrial Resection/Ablation

Franklin D. Loffer, M.D.
Associate Clinical Professor
Department of Obstetrics & Gynecology
University of Arizona
The first thing that must be met for expectations of endometrial ablation to be realistic is the proper selection of patients. The procedure was designed for patients with:

* Menorrhagia
* Failed conservative therapy
* Especially normal uterine cavities
* No abnormal histology
* Desire no further child bearing
* Desire to preserve their uterus
* Where amenorrhea is not required
* Who do not have significant dysmenorrhea

In addition to the above criteria, its use in conjunction with submucous fibroid resection will increase the success rate in patients with menorrhagia who are not desiring fertility.

Available methods for endometrial destruction include the use of the Nd:Yag laser, the resectoscope and new thermal balloon systems. While the majority of cases are done using the resectoscope, the ease of use and uniformity of results suggests that the new thermal balloon system will become more commonly employed especially by those physician not using the other methods.

There are several end points that can be used in describing what can be expected from endometrial ablation. They are:

* Amenorrhea rate
* Eumenorrhea rate or better
* Patient satisfaction
* Hysterectomy rate
* Cost

There appears to be little difference in results whether the Nd:Yag laser or the resectoscope is used for endometrial ablation. In both modalities there is some increase in bleeding the longer patients are followed. This is not to say that there will be a large number of failures but rather over a long period of time the endometrium has a tendency to regenerate and failures can be found many years after the initial procedure.

Amenorrhea rates generally fall in a range from 25-30% with hysterectomy rates falling between 10 and 15%. The majority of hysterectomies are done for pain rather than heavy bleeding.

In assessing patient satisfaction with endometrial ablation, there is evidence to suggest that older patients tend to be more satisfied with the procedure than younger patients and those with concomitant pain less satisfied than those with a pure menorrhagia. In studies where patients have been randomized to endometrial ablation and hysterectomy there is a higher percentage of patients who are satisfied with the hysterectomy than with endometrial ablation but in most cases there is no statistical difference between the two methods of treatment. In the one study where there was a statistical difference, it would appear that unrealistic patient expectation for endometrial ablation was the reason for the lack of satisfaction. It was clear in these studies that there was a higher rate of complications with hysterectomy but a lower rate of the need for further surgery.

Patients will have a hysterectomy after endometrial ablation for all the same reasons that any patient might undergo a hysterectomy. They include problems involving ovarian tumors, CIN, enlarging uterine fibroids, development of pelvic prolapse, only a very few relate to the previous endometrial ablation. While there will be some hysterectomies for
Loffer Endometrial Resection/Ablation

menorrhagia there would appear to be a disproportionate number of patients who develop pain. The problems of pelvic pain and dysmenorrhea following endometrial ablation does not appear to be related to the creation of adenomyosis but more probably relates to the creation of small hematometria.

There is little as yet in the literature to show that endometrial ablation has reduced hysterectomy rates. This apparently anomalous results may be explained if endometrial ablation is bringing more women into surgical treatment of menorrhagia. These would be women who otherwise would have declined a hysterectomy.

When the initial costs of endometrial ablation are compared to hysterectomy multiple studies have shown endometrial ablation is the least costly. LAVH's are the most expensive hysterectomy followed by total abdominal hysterectomy and vaginal hysterectomy. It is necessary to factor in further medical expenses when looking at cost advantages and the longer patients are followed, this gap will narrow since some patients who had an endometrial ablation will eventually require a hysterectomy. It would appear that over 50% of patients would have to come to hysterectomy before the cost advantage of endometrial ablation is lost. In addition, there are potential future surgical costs to hysterectomy such as the development of an enterocele which would less likely develop after endometrial ablation.

All studies comparing endometrial ablation to hysterectomy show:
* shorter surgery time
* less pain
* faster recovery
* less complications
* lower costs
* less blood loss

In view of these facts it is difficult to understand why more gynecologists have not adopted endometrial ablation into their armamentarium of surgical procedures. The answer most likely lies in the fact that it is deceptively skill dependent in order to achieve good results. For that reason, the newer global endometrial ablation methods which require less skill and achieve more uniform and reproducible results may make endometrial ablation more readily available to patients.
Long Term Results

Patient Satisfaction

Hysterectomy Rates

Cost


Hysteroscopic Management of Abnormal Uterine Bleeding: Polyps and Myomas

Linda D. Bradley M.D.
Director of Hysteroscopic Services
Department of Gynecology and Obstetrics
Cleveland Clinic Foundation
Introduction

Abnormal uterine bleeding accounts for many gynecologic visits. A thorough physical examination, medical evaluation, and trial of medical therapy are warranted before recommending a surgical approach to the treatment of menstrual dysfunction. Recommending a 'minimally invasive surgical’ procedure to a patient with an undetected hormonal imbalance (manifesting in anovulatory dysfunctional uterine bleeding) or a treatable coagulopathy should be avoided.

Dramatic increases in the number of patients treated by hysteroscopic techniques (ablation, polypectomy, and endomyometrial resection) have occurred since the 1980’s. Fueled by consumer demands, decreasing hysterectomy rate’s and Insurance Company’s refusal to authorize hysterectomies, other approaches to the management of menstrual dysfunction are necessary. Increasingly, American women are seeking “alternatives to hysterectomy," as women realize a 30% chance of a hysterectomy during their lifetime. Now there is an alternative for 30-40% or more of these patients who have been advised to undergo a hysterectomy. Many studies have noted that as many as 33-50% of patients with menometrorrhagia have myomata, and an additional 20-30% has polyps. The reported direct and indirect costs for hysteroscopic procedures are on the average, only 50% of the combined costs of a hysterectomy.

There exist a myriad of surgical techniques are for intrauterine surgery. Physicians who are experienced, technically skilled, proficient, and who have additional training in hysteroscopic surgery are noted to have safer, shorter, and more successful outcomes. Those without “hands on training” should be proctored during their initial cases. Unfortunately tragic accidents and death during operative hysteroscopy have been reported, most due to complications from excessive fluid absorption, or uterine perforation. In an effort to improve the safety of intrauterine surgery, authoritative guidelines have been published.

Intrauterine Surgical Techniques

Endometrial Polyps

Endometrial polyps are common and present throughout the reproductive life cycle. Clinically they account for 6.8%-20% of all cases of menometrorrhagia in women age’s 20-40 years. The incidence of polyps in IVF patient’s ranges from 6-44% compared to 1.2% of patients reported by Cooper, undergoing hysteroscopic sterilization. Risk factors for endometrial polyps include the presence of cervical polyps and age. The incidence increases in each decade of life.

Endometrial polyps are a frequent cause of abnormal uterine bleeding in the perimenopausal and postmenopausal years. Symptoms are variable and include watery discharge, intramenstrual staining, severe dysmenorrhea, sterility, dyspareunia, and menometrorrhagia. These polyps are usually benign, can be multiple or solitary, and may fill the majority of the endometrial cavity. Endometrial polyps are also associated with prolonged Tamoxifen use.

It is also important to differentiate between endocervical and endometrial polyps. Patients with cervical polyps have approximately a 25% risk of also having endometrial polyps. Endometrial polyps are more often associated with other histologic abnormalities than cervical polyps.
Bradley Hysteroscopic Polypectomy & Myomectomy

Polyps may be detected by office hysteroscopy, filling defects on hysterosalpingogram, SIS, or endometrial biopsy. The location, number, and size of polyps are best determined with office hysteroscopy or SIS. A negative conventional transvaginal ultrasound cannot reliably exclude polyps because they often appear hyperechoic and may be masked by secretory endometrium. Difficulty may also occur in differentiating endocervical from endometrial lesions. The size and position of the polyps may determine whether office removal is feasible: large or multiple polyps may best be removed in the outpatient setting under anesthesia.

In the past, simple twisting or avulsion of the polyp or blind curettage was the surgical treatment of choice. However, this treatment often leaves polyp fragments or the entire polyp present. Approximately, 10% of polyps remain in situ after curettage. Word, reported a series of 512 hysterectomies preceded by blind D&C, with 49 residual polyps noted. Englund, discovered 33 residual polyps from 124 hysterectomies. Polyps are often missed in the fundus and cornual regions.

In a recent study by Townsend, 110 postmenopausal women presented with greater than 6-month history of post-menopausal bleeding. Evaluation and surgical therapy revealed a surprisingly high number of women with endometrial polyps (42/110,) which is higher than the literature has previously reported. These patients were treated with either resectoscopic polypectomy and/or endometrial ablation. Both groups had high patient satisfaction rates after the procedure and resolution of their bleeding disorder. It is not necessary to ablate the entire endometrial cavity after removing the polyp, since success rates are similar. Likewise, Cravello found high surgical success with hysteroscopic polypectomy: 86.2% success measured by patient satisfaction questionnaires.

Technique of Endometrial Polypectomy

Using a hystereoresectoscope and a liquid distending medium the endometrial polyp may be identified and resected using a cutting loop: the base of the polyp may be coagulated, cut, and/or removed with a polyp forceps. Although not as effective, the polyp can be detected with the hysteroscope and removed by either sharp curettage of the endometrial cavity or with an endometrial polyp forceps. The polyp rarely bleeds, however, if this occurs, the base can be coagulated with the wire resectoscopic loop or rollerball. If a blind procedure, such as a D&C, is performed, repeat hysteroscopy at the completion of the procedure to insure complete removal of the polyp. The specimen should be sent for histological examination to exclude atypical changes or cancer.

The 1988 AAGL membership survey on operative hysteroscopy revealed that polypectomy was the second most common operative hysteroscopic procedure performed. Since then, the rates have continued to increase, along with more complex resectoscopic procedures.

Submucous Myoma

Uterine fibroids are the most common solid pelvic tumor in women. Rarely, malignant, but often present, they require appropriate management and therapy. The prevalence of fibroids is higher in the older (>25, than younger patient), more common among African Americans than Caucasians or Asians. The peak incidence is from age 35 to 45 years. Approximately, 30% of whites have fibroids vs. 50-70% of blacks. Of note, only 30% to 50% of patients with fibroids have symptoms related to them. Approximately, 18,000 hysteroscopic or laparoscopic myomectomies are performed annually in the USA.
Bradley Hysteroscopic Polypectomy & Myomectomy

Intrauterine pathology (polyps and fibroids) is detected in 5-10% of infertility patients, and up to 33% in-patients with recurrent pregnancy loss. Second and third trimester losses are more commonly associated with congenital uterine anomalies and submucosal fibroids. The prevalence is not known, but appears to be around 10-30%.

Submucous myomas cannot usually be identified during a bimanual examination. Suspect a submucous myoma when the patient presents with profound anemia, menometrorragia, clots, “gushing or flooding,” severe dysmenorrhea, recurrent miscarriages, or unexplained vaginal discharge.

Ultrasonography may demonstrate a hyperechoic region within the endometrial canal. The hysterosalpingogram may demonstrate an irregular cavity or a filling defect. Often endometrial biopsy will not detect the uterine fibroid -- operative notes from patients with prior D&Cs often state that an irregular surface was felt. Confirmation is aided by office hysteroscopy/or SIS.

Preoperative Assessment of Patients with Suspected Submucous Myomas

Successful outcome following resectoscopic myomectomy requires expert pre-operative evaluation. It is necessary to establish the size, location, number and degree of intramural involvement of uterine fibroids before attempting surgery. A decrease in the number of complications such as fluid overload, burns, perforation, and incomplete resection occurs with thorough pre-operative studies. Consider newer office techniques of uterine evaluation, utilizing SIS or hysteroscopy before resectoscopic myomectomy or in the evaluation of abnormal bleeding. Recent studies reveal that SIS helps to determine the number and extent of intramural component of the uterine fibroid. Compared with hysteroscopy, transvaginal ultrasonography has the additional advantage of mapping the size and location of submucous, intramural, and subserous myomas more precisely. Cicinelli et al reported the benefits of transabdominal SIS over hysteroscopy, and conventional TVUS. Transabdominal SIS more accurately detected fibroid size (as noted at hysterectomy), than did TVUS or hysteroscopy.

Preoperative evaluation will facilitate intra-operative treatment. Important clinical decisions are noted before surgery. The patient can be informed that removal of her fibroids may require two or more procedures, and if there is a large degree of intramural extension or may be better served having laparoscopic or abdominal myomectomy. Wamsteker et al. noted that the more extensive the intramural involvement, the chance to achieve complete resection decreased and the mean number of procedures to achieve complete resection increased. Diagnostic hysteroscopy is extremely helpful in identifying pedunculated fibroids; however, does not offer a precise evaluation of the size or intramyometrial extension of large tumors.

Additionally, pre-operative evaluation may delineate need for pretreatment with GnRH agonists prior to resectoscopic myomectomy. If hysteroscopy shows a uterine fibroid that is larger than 5 cm or fills more than 60% to 75% of the uterine cavity, GnRH suppression should be strongly considered. Rarely should a novice approach a resectoscopic myomectomy if the lesion is larger than 3 cm. One can expect that the uterine fibroid will shrink by 30% to 50% during GnRH treatment. The smaller fibroid facilitates removal of the mass, requires less distending medium, reduces blood loss, and less time is required for removal.

If the patient is anemic and has a very large submucous fibroid, GnRH therapy can be used for 2 months to 4 months to correct the anemia as well as to shrink the uterine...
Bradley Hysteroscopic Polypectomy & Myomectomy

fibroid. As the fibroid undergoes hyaline degeneration, necrosis, and infarct, approximately 2% of patients may experience bleeding heavy enough to warrant emergent resectoscopic myomectomy or hysterectomy.

If the fibroid is less than 4 cm, the patient can be scheduled during the early proliferative phase for resectoscopic myomectomy. Short term use of Depot-Lupron during the mid-luteal phase (day 20 to 23) and scheduling surgery 4 to 5 weeks later has been advocated by some. In addition to the size of the submucous myoma, the size of the uterine cavity should be considered. Patients with uterine cavities greater than 12 cm to 14 cm are difficult to treat since maintenance of intrauterine distention is more difficult.

O’Connell et. al. recently evaluated postmenopausal women presenting with abnormal bleeding utilizing endometrial biopsy combined with SIS,TVUS, fractional curettage and hysteroscopy in 100 women, aged 42-80 (mean):60; 72% were taking HRT. Most cases had benign findings (52%), but 32% had polyps, 22% had proliferative changes, and 5% had cancer. The results of endometrial biopsy plus SIS agreed with the surgical findings in 95 women, making for a 94% sensitivity and a 96% specificity. Lack of correlation occurred early in their study. The false positive and false negatives occurred mainly in 8 women taking Tamoxifen. If these patients were eliminated, the positive correlation of the triage protocol rose to 97%.

Technique of Traditional Resectoscopic Myomectomy

In 1976, Dr. Neuwirth published the first paper highlighting the use of the resectoscope system in gynecology. He employed the cutting loop to remove fibroids transvaginally. His personal series was recently summarized. Other techniques for removing a uterine myoma include the resectoscopic electrical loop, argon laser, YAG laser, scissors, and KTP laser. However, most physicians are currently using electrosurgery. The electroenergy technique is less expensive, quicker to perform and easy to learn. Results are comparable regardless of technique selected.

The resectoscope was originally used in urologic procedures to transect the prostate. Modification of the urologic resectoscope has revolutionized the practice of gynecologic surgery. Essentially, a continuous flow irrigation channel and an outflow channel permit excellent visualization of the cavity throughout extensive surgical procedures. Blood clots and debris are easily removed. Using the resectoscope loop, one can systematically remove portions of the myoma under direct visualization. A retractable, movable wire loop electrode is attached to the hysteroscope and is activated in the cutting or coagulating mode. Power settings range between 40 watts and 110 watts cut current, and 40 watts to 80 watts coagulating current are often employed. Higher currents are often necessary to remove calcium-laden fibroids.

The approach to hysteroscopic myomectomy is determined by the patients desire for future pregnancy, symptoms, and location of fibroids. Purely intracavitary fibroids can be approached hysteroscopically, the majority of the time. If resectoscopic myomectomy is performed in a reproductive age patient desirous of pregnancy, use the least amount of dampened current (coagulating current) as possible. This will decrease the charring that may lead to adhesion formation. Corson suggests starting at 40-50 watts pure cutting current with a resectoscopic loop and increasing the current upward until the myoma shaves off easily. Likewise, patients having multiple submucous fibroids or “kissing fibroids”, desirous of pregnancy, should have separate surgical resections. This minimizes the risk of dense adhesions forming between treated areas. There is little literature to suggest optimum postoperative management in patients with large surface areas treated by resection. Some
Several surgical options for fibroid removal are possible. The technique used depends on size, number, location, and surgical abilities. Small, 1 cm, or less, pedunculated fibroids, can be twisted off at their base, by use of a Corson myoma grasper or polyp forceps. Always, reinspect the endometrium, to ensure complete removal.

Larger fibroids, 2 cm or greater, can be treated with partial resection and removal of larger portions, quickly with Corson forceps. The pedunculated myoma, divided into quadrants with the resectoscope, will permit easier grasping and removal through the cervix. While these are blind grasping procedures, care must be taken to minimize uterine perforation or cervical laceration. The benefit however, often includes; less OR time, less fluid use, and reduction of complications of fluid overload.

When treating submucous myomas, the hysteroscopist is encouraged to shave the myoma to the adjacent level of the endometrium. During the shaving process, numerous crescent shaped fragments will accumulate, Never go below the level of the endometrial cavity, because hemorrhage, perforation, and fluid overload become a risk. The myometrium feels softer than the surrounding fibroid. While the fibroid appears yellow-white, the myometrium has a fascicular pink appearance. Re-epithelialization of the fibroid bed with endometrium occurs days after surgery.

Avoid transecting the fibroid from its base because grasping and removal become impossible. Remove the fibroid in pieces. The base of the myoma stalk and tortuous surface vessels should be coagulated to decrease blood loss during the procedure. If large fibroid chips obscure the surgical view, the hysteroscopic resectoscope should be removed, channels irrigated, and larger uterine fibroids removed with a pituitary ronqueur, suction curettage, or removed under direct vision with the resectoscope. On occasion removing these chips is quite difficult, and many perforations have occurred when attempting to do so. Rather than repeatedly introducing a curette, allow the myoma fragments to expelled spontaneously. These patients should be told to expect a mild vaginal discharge with possible passage of tissue 1-3 weeks after surgery.

Enucleating the base of the uterine myoma can be enhanced by using the wire loop as a "forcep to lift" the myoma from its cavity or base. If this technique is used, expectant management is recommended because the uterine myometrium will contract around the fibroid and often expel the myoma, similar to the events at laparotomy. Use of dilute vasopressin seems to aid in this activity.

The most important aspect of hysteroscopic surgery involves adequate uterine distention. It is a blessing and hindrance. Overdistention, can “push fibroids into the myometrium”, such that a normal hysteroscopic view may occur, when more pathology is actually present. An essential caveat of hysteroscopic surgery: intermittently deflate the uterus during the resection. Otherwise, your surgical procedure may only include the “tip of the iceberg”. Usual distention requires between 70-100 mm Hg intrauterine and lower pressures will permit the intramural component of the fibroid to be visualized. Work with the lowest distention in order to remove the bulk of the myoma.

All tissue that has been removed should be sent for pathologic analysis. Less than 0.1% of patients with uterine fibroids will have an associated leiomyosarcoma. However, submucosal fibroids have a higher chance of sarcomatous degeneration. 2.8% has been documented. One cannot differentiate a uterine fibroid from a sarcoma by gross examination.

Employ laparoscopy liberally during your “early learning curve”. Many physicians routinely use laparoscopy while performing resectoscopic myomectomy or ablation until they...
have performed approximately 5 to 10 resectoscopic myomectomies. If your index of suspicion is high for a uterine perforation or bowel injury, perform laparoscopy. Some physicians have advocated instillation of a non-conductive solution (normal saline) into the peritoneal cavity to act as a "heat sink," which acts to dissipate heat, and protecting the bowel. I don’t do this with my procedures. Generally, a minimal amount of distending medium remains in the peritoneal cavity after a resectoscopic myomectomy. This fluid need not be aspirated or irrigated, unless large volumes are refluxed. Passive reabsorption of the fluid will occur. More fluid is absorbed through the uterine veins, than through the peritoneal cavity.

**CIRCON (ACMI) VaporTrode**

**Rapid Vaporization**
- Unique design vaporized myomas
- Improved coagulation zone

**Better Visibility**
- No need to remove tissue chips
- Reduced number of tissue fragments
- Minimal bleeding during procedure

**Decreased Procedure Time**
- High current density for balanced vaporization and coagulation
- Quickly excised tissue masses

Complications of Resectoscopic Myomectomy

Hemorrhage is rare after resectoscopic myomectomy. Some physicians recommend intracervical injection of a dilute solution of Pitressin (1 ampule: 50 ml saline) to induce vasoconstriction to decrease uterine bleeding or hemorrhage that may occur during the procedure. Prior to dilation and resection, 10 ml to 20 ml, are injected paracervically, at the 2, 6, and 10 o'clock positions as an intracervical stromal injection, just at the vaginal vault. Due to vasospasm and vasoconstriction, less fluid may be used or absorbed during surgery. This may be advantageous when long procedures are anticipated.

In the event of hemorrhage, the bleeder is identified and coagulated with the roller ball or wire loop. A pediatric foley catheter can also be inserted in the uterus and inflated to 15 ml to 30 ml. When the patient is in the recovery room, the catheter can be deflated by half 2 to 3 hours after surgery. The remaining fluid removed 1-2 hours later. If the patient has no active bleeding, she can be discharged.

Alternatively, uterine hemorrhage can also be successfully controlled with a vasopressin impregnated uterine packing. A one inch uterine gauze soaked in a dilute mixture of 1 ampule Pitressin in 50 ml saline, and inserted into the uterine cavity has also successfully controlled postoperative hemorrhage.

Reproductive-age patients, desiring future pregnancies may benefit from estrogen supplementation postoperatively. For patients receiving Depot-Lupron preoperatively, estrogen therapy can be used to decrease intruterine synechia formation or to enhance endometrial regeneration. To induce endometrial sloughing, Premarin 1.25 mg q.d. or b.i.d. for 30 days followed by Provera 10 mg for 12 days has been advocated. The post- resectoscopic myomectomy synechiae rate is less than 5%.

During resectoscopic procedures, electrolyte-free solutions can rapidly enter the arterial and/or venous channels, which in severe cases cause hyponatremia, pulmonary...
Bradley Hysteroscopic Polypectomy & Myomectomy

edema, water intoxication and death. Even with low pressures, intravasation may occur. Factors associated with intravasation include: the size of the resected area, the amount of vasculature exposed during the procedure, the length of the procedure, and the permeability of the fallopian tubes.

The total amount of glycine or sorbitol required for each case will vary, depending on the number and size of myomas resected, size of uterine cavity, and skill of the operator. The amount of fluid not accounted for (i.e., absorbed intravascularly), rather than the total used is the most important variable. The average fluid volume infused may range from 1 liter to 15,000 ml. The deficit is what is crucial.

Complications related directly to the resectoscopic myomectomy are rare but can include fluid and electrolyte imbalance caused by the distending medium. Judicious measurement of intake/output is critical. Remember that, the manufacturer, overfills the bags up to 10%. Therefore, it is better to discover that the output is greater than the input (unless the case is bloody).

The TURP syndrome can occur in patients treated with glycine or sorbitol. This syndrome includes: hyponatremia/hypoosmality, dilutional anemia, or pulmonary edema. Neurological symptoms including muscle twitching, seizures, and comas can occur if prompt diagnosis and treatment are not instituted. The metabolic products of absorbed glycine are converted into ammonia and may cause transient decrease in visual acuity due to the inhibitory effect of glycine on the retina. Generally, these conditions will self-correct within a short time with fluid restriction and diuretic administration. Monitoring input and output every 5 minutes is important when glycine or sorbitol is used. Many new automated fluid management systems now continuously provide the surgeon with this data. The important criteria include a documented accuracy rate, real time inflow, outflow and deficit, and the ability to track through bag/bottle changes without interruption. If the deficit is 1000 cc, then stop the procedure and obtain stat electrolytes, continue cautiously if less than 5-10 minutes from completion. If one cannot account for more than 1500 ml to 2000 ml of the distending medium, then the myomectomy should be abandoned, electrolytes monitored, patient administered 10 mg furosemide, and the patient rescheduled for a completion procedure if symptoms recur. Stricter fluid restriction of 700 ml to 900 ml has been advocated in older patients, and those with compromised pulmonary function, or heart failure. By adhering to this strict protocol, complications are minimized.

The incidence of fluid overload occurs in 1-2% of resectoscopic procedure and is more common when the surgery lasts longer than 50 minutes, in the presence of larger fibroids, or with cervical laceration.

McCausland noted that postoperative infection after operative hysteroscopy was rare. However, infections are more common in patients with risk factors for pelvic inflammatory disease including: secondary infertility bacterial vaginosis, prior pelvic infection, adnexal tenderness, adnexal mass, prior infertility, or undocumented salpingitis. These groups had the highest risk of developing a postoperative tubal ovarian abscess after therapeutic hysteroscopy. Patients with multiple risk factors should receive prophylactic antibiotics before resectoscopic myomectomy.

Resectoscopic Myomectomy Outcome

Well-selected patients having a resectoscopic myomectomy are pleased with their surgical procedure. After the first months of therapy 80% to 90% of patients report improvement in menorrhagia. Recurrent symptoms occur in less than 20% of patients. In patients who must undergo another myomectomy, new myomas or intramural myomas that begin to project into
Bradley Hysteroscopic Polypectomy & Myomectomy
the endometrial cavity after the submucous component has been removed may be found.
Complication rates of less than 5% have been reported.
Incomplete resection of myomas may occur on occasion, due to fluid overload, perforation, prolonged operating time, or excessive blood loss.
Incomplete resection of a submucosal myoma may occur if there is an intramural component also. If the procedure cannot be completed wait for several months after the initial procedure to determine the natural outcome. Symptoms may not reoccur, because the procedure may render the remaining fibroid nonviable. The remaining fibroid may prolapse on its own.
Results of Hysteroscopic Resection of Polyps/Fibroids

<table>
<thead>
<tr>
<th></th>
<th>Resection of polyps</th>
<th>Resection of fibroids</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n=116</td>
<td>n=232</td>
<td>n=348</td>
</tr>
<tr>
<td>Lost to follow-up</td>
<td>5 (4%)</td>
<td>17 (7%)</td>
<td>25 (7%)</td>
</tr>
<tr>
<td>Success</td>
<td>101 (87%)</td>
<td>188 (81%)</td>
<td>289 (83%)</td>
</tr>
<tr>
<td>Failure</td>
<td>10 (8%)</td>
<td>27 (11%)</td>
<td>37 (10%)</td>
</tr>
</tbody>
</table>


Results of Hysteroscopic Treatment of Submucosal Uterine Fibroids

<table>
<thead>
<tr>
<th>Author</th>
<th>Number of patients</th>
<th>Surgical Procedure</th>
<th>Follow-up</th>
<th>Eumenorrhea(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neuwirth (78)</td>
<td>4</td>
<td>Resectoscope</td>
<td>9-18 months</td>
<td>4/4 (100)</td>
</tr>
<tr>
<td>DeCherney (84)</td>
<td>8</td>
<td>Resectoscope</td>
<td>1 yr.</td>
<td>8/8 (100)</td>
</tr>
<tr>
<td>Neuwirth (83)</td>
<td>26</td>
<td>Resectoscope</td>
<td>1 yr.</td>
<td>17/26 (65)</td>
</tr>
<tr>
<td>Valle (87)</td>
<td>34</td>
<td>Scissors</td>
<td>1 yr.</td>
<td>34/34 (100)</td>
</tr>
<tr>
<td>Hallez &amp; Perino (88)</td>
<td>300</td>
<td>Resectoscope</td>
<td>1 yr.</td>
<td>299/300 (99)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>372</strong></td>
<td></td>
<td></td>
<td><strong>362/372 (97)</strong></td>
</tr>
</tbody>
</table>


Improving Surgical Success of Hysteroscopic Polypectomy and Myomectomy (general housekeeping pearls)

- Consider laminara placement--to decrease risks of cervical laceration
- Avoid use of obturators--insert hysteroscope under direct vision
- Have an excellent collection pouch system under the buttock--don’t get your feet wet
- Essential to have a reliable fluid management system
- Activate the electrode under direct visualization or as it is moved back into the scope
- Appropriate distension media
- G-U tubing with Y connectors
- Stop when greater than 1000-1500 cc of glycine absorbed
- Be aware of symptoms of congestive heart failure/pulmonary edema when saline is used

Resectoscopic Myomectomy/Polypectomy Complications--Intra/Post-Op

- Traumatic
  - rupture of uterus
  - rupture of hydrosalpinx
  - uterine perforation
  - cervical laceration
- Hemorrhage
Bradley Hysteroscopic Polypectomy & Myomectomy

- Distension
  - dilutional hyponatremia
- Electrical/Laser damage
- Air embolism

Resectoscopic Myomectomy: Advantages of Pitressin Use
- Vasoconstriction-less bleeding intraoperatively
- Less tubal regurgitation due to uterine muscle contraction
- Softens cervix
- Reduced fluid intravasation
- Technique
  - 20 units Pitressin in 100 cc Saline

General Guidelines to Prevent Hysteroscopic Complications

1. Keep meticulous account of amount of fluid used. Designate one member of the nursing staff to tally input/output every 5 minutes. Consider using an automated system with real-time, accurate inflow, outflow, and deficit data.
2. Volume of fluid instilled and recovered must be accurately recorded
3. Consider regional anesthesia when possible (if laparoscopy is not planned). This allows the diagnosis of symptomatic hyponatremia early (e.g., nausea/vomiting, mental status changes, and pulmonary edema.
4. Be prepared to stop procedure and plan for a second procedure when excessive fluid absorption has made continuation unsafe.

Summary

The use of the uterine resectoscope is not widespread. The blind D&C is a dead dinosaur. The days of never visualizing the endometrial cavity to treat intrauterine disease is over. There are many benefits of minimally invasive intrauterine surgery: quicker recovery, decreased costs and high patient satisfaction rates. Increase your office diagnostic acumen, so that your patients can benefit from the newer minimally invasive techniques that are available.

The universal axiom of intrauterine surgery requires: pre-operative tissue sample, proper patient selection, pre-operative evaluation, familiarity of instruments used, and skillful intraoperative techniques. Your skills will improve over time, thus enhancing patient satisfaction rates. It is easy to transition the use of the hysteroscope as a diagnostic tool to its use as a therapeutic tool.
References

18. Cicinelli E, Romano F, Anastasio P, Blasi N, Parisi C, Galantino P. Transabdominal sonohysterography, transvaginal sonography, and hysteroscopy in the evaluation of
34. Frideman AJ. vaginal haemorrhage associated with degenerating submucous leiomyomata during leuprolide acetate treatment. Fert Steril 1989;52:152-54
Bradley Hysteroscopic Polypectomy & Myomectomy

Non Hysteroscopic Endometrial Ablation
Endometrial Ablation

Franklin D. Loffer, M.D.
Associate Clinical Professor
University of Arizona
Traditional methods of endometrial ablation including Nd:Yag laser, resectoscopic ablation, and resection have, in expert hands, yielded very good results with minimal complications. In spite of their apparent simplicity, these procedures are very skill dependent and good results are not necessarily easily achieved.

The recent development of new non hysteroscopic endometrial ablation (NHEA) technologies has provided several benefits. Their simplicity of application has allowed physicians without hysteroscopic skills to provide endometrial ablation to their patients. This should result in more patients being offered this method of therapy as opposed to the ineffective D&C or more radical hysterectomy. Furthermore, the NHEA technologies tend to be more passive and require little in the way of intrauterine manipulation. Ultimately this should result in less anesthetic requirements and easier implementation in non-operating room (office) settings.

Virtually all the new technologies are blind procedures. Many are not suitable for the use in patients whose uterine cavity is distorted by a septum, large fibroids or polyps. Therefore, the size and shape of the cavity must frequently be determined by either ultrasound or hysteroscopy in addition to knowing the endometrial histology.

NHEA technology can be divided into 5 types. They are: 1) heated fluid systems; 2) bipolar and monopolar electrical systems; 3) laser energy; and 4) microwave and radiofrequency energy and 5) cryotherapy

**Heated Fluid**

The only current heated fluid system available in the United States is ThermaChoice™ Uterine Balloon therapy (Gynecare Products Division, Ethicon, Inc., Somerville, NJ).

It uses a dedicated generator which monitors pressure, temperature and treatment times. A disposable 5 mm probe with a latex balloon at one end containing a thermistor, heating element, and mixer is inserted into the uterine cavity. After demonstrating integrity of the catheter, it is pressurized to 170-180 mm Hg and heated to 87 degrees for 8 minutes.

In a randomized study comparing the ThermaChoice Uterine Balloon Therapy System to standard roller ball ablation statistical similar decreases in days or menstrual flow and diary scores were shown.

The Cavertern™ system (Walsten Medical, Morges, Switzerland) uses a battery operated generator and a disposable catheter with a silastic balloon. At the distal end of the 8 mm catheter is a heating element, thermistor, and mixing unit. Treatment temperature is 75 degrees for 30 minutes with a balloon pressure of 170-180 mm Hg. Comparative studies have not been done with this system but it would appear to have results similar to the ThermaChoice.

The Hydrothermablator™ (BEI Medical Systems, Hackensack, NJ) circulates heated saline into the uterine cavity at 90 degrees C for 10 minutes. A pressure of 75 mm Hg is used which prevents outflow through the tubes. Hysteroscopic monitoring of the uterus is done concomitantly with the therapy. A PMA study comparing it to the roller ball ablation is currently being finalized.

The EnAbl System (US Surgical, Norwalk, CT) also circulates heated saline for 15 minutes at a temperature of 75-85 degrees C. Clinical studies are not available.

**Electrical Energy**

The Vesablate™ System (Vesta Medical, Valley Lab, Boulder, CO)
Loffer Non-hysteroscopic Endometrial Ablation

uses a modified electrosurgical generator and disposable, inflatable device containing 12 electrodes. Each electrode is controlled by a separate thermistor which after a warm up interval keeps the electrode at 75 degrees C for 4 minutes. A continuous (cutting) current of 45 watts is used in this unipolar system. The results have been compared in a PMA study to endometrial resection followed by roller ball ablation and were similar. This procedure has been approved by the FDA. It is not yet marketed.

A true bipolar system currently being evaluated is the Novasure™ (Novacept, Palo Alto, CA). This system uses a dedicated bipolar high frequency electrosurgical generator and a disposable ablation device. The intrauterine portion is a mesh system which causes electrical current to flow from one portion of the mesh to the other. The unique aspects to this system are that the uterine cavity is brought into close proximity to the electrodes by creating a negative intrauterine pressure. Preliminary studies suggest that this procedure will create excellent results and carries with it the advantage of a treatment time of between 1 and 2 minutes.

Microwave Endometrial Ablation

The MEA system (Microsulis, Waterlooville, New Hampshire, UK) is a microwave system composed of a computerized control unit and coaxial microwave cable and re-usable uterine probe. The energy is delivered through an 8.5 mm catheter using a power of 30 watts for a mean treatment time of 147 seconds. Comparative clinical studies have not been done but results appear similar to other global methods.

Radiofrequency electromagnetic energy ablation

The Menostat™ system, Rocket Medical, Watford, UK, uses a conductive intrauterine probe and an external electrode around the patient's waist. Comparative clinical studies have not been done but results appear similar to other techniques with some suggestion that a higher failure rate existed. Serious complications have developed with this device and further safety enhancements are needed before further use can be considered.

Cryotherapy

Cryotherapy for uterine ablation is being evaluated by (Cryogen Inc., San Diego, CA) and Gynecare (Ethicon, Somerville, NJ). Preliminary studies suggest results are similar to other ablation methods. Long term results are not yet available and a pivotal clinical trial is being conducted.

Photodynamic Ablation Therapy

An interesting concept for endometrial ablation is photosensitization endometrium and subsequent treatment with light. Interaction between light and the sensitized endometrium induces oxidation reactions. Singlet oxygen which is produced by such reactions is toxic to the endometrium. This is an experimental technique and no clinical trial are available to evaluate.

Laser Energy

The GyneLase™ or the Elitt™ (ESC Medical Systems, Ltd. Israel) uses a fiberoptic delivery system similar to an IUD which is opened up inside the uterus. A continuous wave of GaALAs diode laser using powers up to 21 watts treats the endometrium. This system is currently being investigated and clinical results have not been published.
Laparoscopic Surgery: Examining the Indications and the Evidence

David L. Olive, M.D.
Private Practice
San Mateo, CA
Laparoscopy, like any other tool in medical care, provides the opportunity for both promise and abuse. A key aspect for understanding the role of this technique is a solid foundation grounded in the scientific literature for the field. This lecture will discuss how to evaluate the literature, how to find the pertinent literature to address a given question, and finally what the literature says regarding laparoscopic procedures, by way of several examples.

When laparoscopic intervention is used to treat disease, demonstration of value involves the development of a treatment trial. Such trials can take on many forms. The simplest is the uncontrolled trial, where outcomes are measured for laparoscopic intervention only. While this may give us some idea of how a treatment works, however, it fails to allow us to compare our experimental treatment to existing interventions. To test the comparative value, a controlled trial is needed. There are many types of controlled studies: retrospective, prospective, historically-controlled, and concurrently-controlled are examples. All have limitations, some greater than others. However, the gold standard for treatment trials is the randomized clinical trial, or RCT. However, not all randomized trials are created equal: methods of allocation, inclusion-exclusion criteria, and methods of analysis all affect the value of the trial. Finally, when a number of RCTs exist, they can be pulled together into a systematic review; if the trials are sufficiently similar, they can be statistically analyzed together as a Meta-analysis. The meta-analysis currently represents our best method of assessment, save for a very large, definitive RCT.

In the current electronic age of information, access to the literature has become impressively easy. The internet allows access to a variety of search engines, many of which make use of Medline at the National Library of Medicine. However, not all journals are represented on Medline; it has been estimated that less than 25% of all randomized trials in Obstetrics and Gynecology can be found there. Other databases exist, but they too are incomplete. However, a recent development is the Cochrane Library, a growing database of meta-analyses, systematic reviews, and high quality clinical trials. The database can be obtained by subscription, and can be accessed either by the internet or CDrom. It currently provides the most complete accumulation of high-quality studies available.

What meta-analyses exist for laparoscopy? The use of endoscopy for treatment of ectopic pregnancy has been extensively evaluated, with results clearly demonstrating it to be less successful than open surgery, due to a higher persistent trophoblast rate. However, other advantages (cost, minimal invasiveness) may outweigh this factor. Interestingly, laparoscopic surgery has proven to be superior to methotrexate treatment, except perhaps in patients with a low hCG level. Meta-analyses have also been used to evaluate the role of laparoscopic treatment of endometriosis for fertility enhancement, ovarian drilling for ovulation induction, repair of inguinal hernia, and laparoscopy versus minilaparotomy for tubal sterilization. These will be reviewed.

Readings:
Hysteroscopic Procedures: Examining The Indications and the Evidence

David L. Olive, M.D.
Private Practice
San Mateo, CA
Hysteroscopy, like laparoscopy, has blossomed in the last decade in terms of the quality of equipment and potential for operative procedures. However, like laparoscopy, it requires solid evaluation so that the indications, contraindications, and precise role of this tool can be defined for clinical practice.

Randomized trials are clearly important in the assessment of hysteroscopy. However, the inherent difficulty in mastering and maintaining skills with this technique introduces a new issue to understanding the medical literature: the surgical RCT. Unlike medications, which are administered uniformly by virtually all physicians, surgery is physician dependent. Thus there are inherent limitations in the generalizability of surgical studies, as well as the appropriateness of systematic reviews and meta-analyses in application to one’s own practice. Furthermore, there are issues with study design unique to the surgical RCT, and these must be evaluated for each study reviewed. For instance, the skill of the surgeon in performing one technique or the other in a comparative trial may well differ, influencing results. Also, if a new technique is still in its evolutionary phase, the results of the trial may be inapplicable and outmoded at completion as the procedure may have changed drastically over time.

Few randomized trials have been conducted for hysteroscopy, and even fewer meta-analyses exist. The Cochrane Library contains two. One meta-analysis compares endometrial resection/ablation to hysterectomy for heavy menstrual bleeding. In combining five RCTs on the subject, the conclusion is that endometrial destruction offers a reasonable alternative to hysterectomy, with both showing high levels of effectiveness and patient satisfaction. In addition, pre-operative endometrial thinning agents have been evaluated prior to hysteroscopic surgery for heavy menstrual bleeding. Combining eight studies, GnRH analogues were shown to be associated with a shorter duration of surgery, greater ease of surgery, and a higher rate of post-operative amenorrhea.
Readings:

PART IV

PRE-TEST QUESTIONS

ANSWER KEY
Pretest Questions

1. Which of the following hysteroscopic endometrial ablation methods has been shown to be associated with the greatest number of uterine perforations?
   A. Electrocoagulation
   B. Electrosurgical Resection
   C. Laser Vaporization
   D. Electrosurgical Vaporization

2. Which of the following is true regarding efficacy of various methods of endometrial ablation?
   A. All are approximately equal in experienced hands
   B. Electrosurgical resection is the most efficacious while laser vaporization is the least efficacious
   C. Non hysteroscopic endometrial ablation with the thermal balloon is less effective than hysteroscopic methods
   D. Failure rates seem to stabilize after 14 months

3. Which of the following has been shown to reduce the effectiveness of hysteroscopic endometrial ablation (HEA)?
   1. Operating on women >45 years of age
   2. Ablation on patients with adenomyosis
   3. Use of GnRH agonists
   4. Surgeon with less than 10 previous ablation procedures
      A. 1 & 3 Only
      B. 1,2,3 Only
      C. 2,4 Only
      D. 4 Only
      E. None of the above
4. What measures might be expected to reduce the incidence of hysteroscopic distension media absorption?
   1. GnRH agonists
   2. Intracervical injection of dilute vasopressin
   3. Maintenance of intrauterine pressure below mean arterial pressure
   4. Use of resection loop over ball or vaporizing electrode
      A. 1 & 3 Only
      B. 1,2,3 Only
      C. 2,4 Only
      D. 4 Only
      E. None of the above

5. Which of the following non-hysteroscopic ablation (NHEA) methods is based upon radiofrequency electrosurgery?
   A. ThermaChoice balloon
   B. Novasure bipolar device
   C. Cryotherapy
   D. Photoactivated dye

6. Which of the following best describes the pattern of failure rates for hysteroscopic endometrial ablation
   A. Amenorrhea rates increase gradually from 30 to 75%, stabilizing at two years
   B. Amenorrhea rates are initially about 75% then decline gradually plateauing at 30% after two years
   C. Reoperation rates rise gradually over four years to about 30-40%.

7. What best describes patient satisfaction with HEA compared to hysterectomy for Chronic DUB in available randomized trials?
   A. Satisfaction with HEA is greater than hysterectomy
   B. Satisfaction with hysterectomy is greater than for HEA
   C. Satisfaction with HEA and hysterectomy are equal
8. What is the impact of preoperative GnRH agonists on the performance of hysteroscopic endometrial ablation according to available randomized clinical trials.

1. Absorption of distension media is decreased
2. Surgical time is decreased
3. Short term bleeding outcomes are improved
4. Patient satisfaction is increased

   A. 1&3 Only
   B. 1,2 & 3 Only
   C. 2 & 4 Only
   D. 4 Only
   E. All of the above

9. Which of the following are true regarding the performance of myomectomy?

1. Adnexal adhesions are more common following anterior uterine incisions
2. Uterine tourniquets reduce blood loss associated with myomectomy
3. Horizontal uterine incisions increase the risk of uterine bleeding
4. There are no prospective studies comparing laparotomic to laparoscopic myomectomy

   A. 1&3 Only
   B. 1,2 & 3 Only
   C. 2 & 4 Only
   D. 4 Only
   E. All of the above

10. Which of the following are true regarding hysteroscopic myomectomy?

2. Laparoscopic guidance has been shown to reduce the incidence of uterine perforation
3. Unlike endometrial ablation, preoperative GnRH agonists seem to have little benefit
4. Intraoperative ultrasound guidance may reduce the incidence of uterine perforation

   A. 1&3 Only
   B. 1,2 & 3 Only
   C. 2 & 4 Only
   D. 4 Only
   E. All of the above
11. All of the following are false regarding electrosurgical myolysis except
   1. Pregnancy following myolysis have a low incidence of complications.
   2. Long term studies have shown that total uterine volume is reduced by more than 50% following myolysis.
   3. The best results have been reported with myolysis as a single procedure, without additional procedures.
   4. Better bleeding outcomes have been reported in patients treated without preoperative GnRH therapy.

12. The following are true about uterine artery embolization (UAE) except
   1. Both uterine arteries are usually catheterized via the same femoral artery
   2. Submucous myomas may deliver vaginally days to weeks following the procedure
   3. Pregnancy safety following UAE has been well established
   4. Many patients require hospital admission for pain relief

13. Which of the following describe fundamental principles for electrosurgical occlusion (coaptive coagulation) of a 3 mm diameter blood vessel?
   A. Isolation of the vessel
   B. Use of "coagulation" current
   C. Addition of a clip or ligature for safety
   D. Use of bipolar systems
      1. A,B & C Only
      2. A & C Only
      3. B & D Only
      4. D Only
      5. All of the above

14. For optimal laparoscopic suturing
   A. The target area is on the axis between the operator's eye and the monitor
   B. Two laparoscopic needle drivers are used
   C. For intracorporeal knot tying one driver grasps the distal end of the needle
   D. Detachable needles are preferred
      1. A,B & C Only
      2. A&C Only
      3. B & D Only
      4. D Only
      5. None of the above
15. Potential causes of bleeding from pedicles transected with linear cutting-stapling devices include:
   A. Improper selection of staple length
   B. Mechanical failure of the device
   C. Asymmetrical pedicle thickness
   D. Presence of 3 mm diameter vessels in the pedicle
      1. A,B & C
      2. A&C Only
      3. B & D Only
      4. D Only
      5. All of the above

16. Principles of the use of electromechanical morcellators include
   A. Orientation of the long axis of the device perpendicular to the abdominal wall
   B. Advancing the morcellator into the tissue with the dominant hand
   C. Avoidance of the use of grasping instruments on the tissue specimen
   D. Skimming the blade through the tissue, avoiding occupying the entire lumen with specimen
      1. A,B & C
      2. A&C Only
      3. B & D Only
      4. D Only
      5. All of the above

17. Complications of the intraperitoneal rupture of malignant ovarian neoplasms may include
   A. Gas embolism
   B. Compromised prognosis
   C. Increased incidence of wound infection
   D. Laparoscopic port site metastasis
      1. A,B & C
      2. A&C Only
      3. B & D Only
      4. D Only
      5. All of the above
18. Increasing the "Power" of a harmonic scalpel means that
   1. More electrical power is delivered to the handle
   2. The blade oscillates with greater force
   3. The excursion of the blade is increased
   4. More rotational force is transmitted to the blade

19. Which of the following does not describe a function of current electrosurgical generators
   1. Converts wall output (60 Hz) to radiofrequency output (500 mHz)
   2. Creates a direct current
   3. Allows the operator to change the percentage of time that the current is on
   4. Shuts off when target tissue is coagulated

20. Capacitative coupling at laparoscopy is more likely to occur under the following circumstances
   A. Using cutting current
   B. When metal cannula (port) anchors are used around metal cannulas
   C. If the electrode is in contact with target tissue
   D. If the ratio of the electrode diameter to the cannula diameter is high
      1. A, B & C
      2. A & C Only
      3. B & D Only
      4. D Only
      5. None of the above

21. When previous surgery creates the possibility that bowel adhesions exist under the umbilicus, alternate safe
    methods for laparoscopic access to the peritoneal cavity include:
   A. Trans cul-de-sac insufflation
   B. Insertion of the insufflation needle in the left upper quadrant
   C. Transuterine insufflation
   D. Open laparoscopy
      1. A, B & C
      2. A & C Only
      3. B & D Only
      4. D Only
      5. None of the above
22. Laparoscopic retropubic urethropexy
   1. Has been demonstrated as effective at five years as traditional laparotomic approaches
   2. Is facilitated with dissection of a partially filled bladder
   3. Is associated with a shorter hospital stay than the Peyerra procedure
   4. Has usually been performed replicating the Marshall-Marchetti procedure

23. The incision for removal of an unruptured ampullary ectopic pregnancy
   A. Must be longer than when the procedure is performed at laparotomy.
   B. Is created in the proximal aspect of the dilated portion of the tube
   C. Should be made with a laser to minimize endothelial damage
   D. Is made on the antimesenteric side of the tube.
      1. A, B & C
      2. A & C Only
      3. B & D Only
      4. D Only
      5. None of the above

24. Which of the following are true regarding laparoscopic tubal occlusion for female contraception
   A. Should be performed 2-4 cm from the cornua.
   B. Outcomes stabilize at about 2 years
   C. Unipolar technique has been demonstrated superior to bipolar technique
   D. Under the age of 45, age has no effect on failure rates
      1. A, B & C only
      2. A & C only
      3. B & D only
      4. D Only
      5. None of the above

25. Which of the following is true regarding laparoscopic trocar-cannula systems (T-CS)
   1. Those with protective sheaths are associated with fewer bowel and vascular injuries
   2. The abdominal wound does not vary significantly regardless of the T-CS designs provided the
      outside diameter of the device remains the same
   3. Insertion of the initial cannula without pre insufflation of the peritoneal cavity is always
      considered unsafe
   4. It may be appropriate to insert the device at a right angle to the abdominal wall in some
      patients

26. The large caliber blood vessel closest to the umbilicus is usually the
1. Aorta
2. Right common iliac artery
3. Inferior vena cava
4. Anterior division of the internal iliac artery

27. Which of the following is false regarding laparoscopic hysterectomy?
   1. It has been shown to be less costly than vaginal hysterectomy
   2. It comprises a spectrum of procedures that vary according to the relative amounts of vaginal and laparoscopic dissection
   3. It has been shown to be less costly than abdominal hysterectomy

28. Which is true regarding laparoscopic destruction of peritoneal endometriosis?
   1. It may improve fecundity in patients with minimal and mild endometriosis
   2. Is best accomplished with CO2 laser
   3. Has no impact on pelvic pain associated with endometriosis

29. Which of the following is true regarding laparoscopically directed neurectomy for chronic pelvic pain?
   1. Uterosacral nerve ablation (UNA) results in significantly less central pain than no surgery at two years.
   2. Patients undergoing presacral neurectomy (PSN) have significantly less lateral dysmenorrhea and deep dyspareunia.
   3. The combination of UNA and PSN result in a greater reduction in central pelvic pain than either operation alone
   4. Currently available evidence is inconclusive regarding the efficacy of either UNA or PSN.

30. Which of the following factors may contribute to the intravasation of distention media during an operative hysteroscopy?
   A duration of surgery
   B intrauterine pressure
   C depth of myometrial invasion
   D tonicity of solute

   6. A, B & C only
   7. A & C only
   8. B & D only
   9. D only
   10. All of the above
31. As compared to diagnostic hysteroscopy, sonohysterography is:
   A. Equivalent for diagnosing a submucous myoma
   B. Better suited to gauge the intramural depth of a submucous myoma
   C. Prone to over-diagnose an endometrial polyp
   D. Prone to over-diagnose a submucous myoma
       1. A, B & C only
       2. A and C only
       3. B and D only
       4. D only
       5. All of the above

32. Fascial defects at trocar sites should be repaired whenever
   A. A 10mm port is used lateral to the rectus sheath
   B. A port of any size is placed lateral to the rectus sheath
   C. Tissue is forcibly extracted from a site lateral to the rectus sheath
   D. Any 10mm port site is used
       1. A, B & C only
       2. A and C only
       3. B and D only
       4. D only
       5. All of the above

33. The risk of air embolism during an operative hysteroscopy can be reduced by
   A. Keeping the cervix open after dilation
   B. Keeping the patient in Trendelenburg position
   C. Purging air from the fluid inflow lines
   D. Keeping the outflow port of the resectoscope closed
       1. A, B & C only
       2. A and C only
       3. B and D only
       4. D only
       5. All of the above
34. Factors which may contribute to injury to the retroperitoneal vasculature during peritoneal entry include
   A. placing the patient in Trendelenburg position prior to insertion
   B. deviating from the midline
   C. using excessive force
   D. minimizing soft tissue dystocia
      1. A, B & C only
      2. A and C only
      3. B and D only
      4. D only
      5. All of the above

35. Relative contraindications for direct trocar insertion include
   A. extremes of body mass index
   B. prior abdominal surgery
   C. intrauterine pregnancy
   D. reusable trocar cannula systems
      1. A, B & C only
      2. A and C only
      3. B and D only
      4. D only
      5. All of the above

36. In the dorsal lithotomy position, the peroneal nerve can be protected by
   A. Maintaining a high lithotomy position throughout
   B. Tightly padding the lateral aspect of the head of the fibula
   C. Abduction and lateral rotation of the hip joints
   D. Setting both feet flatly into the foot-holds of Allen-type stirrups
      1. A, B & C only
      2. A and C only
      3. B and D only
      4. D only
      5. All of the above
37. The second surgical layer of the pelvic sidewall consists of the
A. Internal iliac vessels and their tributaries
B. The ureter and its nutritive arterial branches
C. The obturator vessels and nerve
D. Internal pudendal, inferior gluteal, and obturator arteries
   1. A, B & C only
   2. A and C only
   3. B and D only
   4. D only
   5. All of the above

38. Which can correctly be stated about the femoral nerve?
   1. It is well vascularized
   2. It travels atop the psoas muscle
   3. In dorsal lithotomy position, it is protected by abduction and external rotation of the hip
   4. It exits the bony pelvis underneath the inguinal ligament

39. Which can be correctly stated about the medial umbilical ligaments?
A. they can be traced back to the origin of the uterine arteries
B. they are lateral to the obturator neurovascular bundle
C. they can be traced superiorly to meet at the umbilicus
D. they are contiguous with the umbilical arteries
   1. A, B & C only
   2. A and C only
   3. B and D only
   4. D only
   5. All of the above
40. Which can be correctly stated about the inferior epigastric vessels?

A. They arise from the femoral vessels
B. They arise from the external iliac vessels
C. They are best identified using transillumination
D. They are located medial to the internal inguinal ring

1. A, B & C only
2. A and C only
3. B and D only
4. D only
5. All of the above

41. When applying electrosurgical energy to tissue, cutting is mostly likely to occur:

A. With larger-surface electrodes
B. On contact with the active electrode
C. With the edge or tip of the electrode
D. When tissue is heated slowly

1. A, B & C only
2. A and C only
3. B and D only
4. D only
5. All of the above

42. Whether electrosurgical cutting or coagulation occurs depending on:

A. rate of rise of tissue temperature
B. concentration of energy
C. electrode surface area
D. applied voltage

1. A, B & C only
2. A and C only
3. B and D only
4. D only
5. All of the above
43. Lateral thermal damage during monopolar electrosurgical cutting can be reduced by:
   A. cutting through tissue with fulguration
   B. using the "coag" waveform
   C. applying higher voltage
   D. using the "cut" waveform
      1. A, B & C only
      2. A and C only
      3. B and D only
      4. D only
      5. All of the above

44. Fundamental differences between "cut" and "coag" waveforms are:
   A. "Coag" waveform has substantially higher peak voltage
   B. "Cut" waveform has lowest peak voltage
   C. "Coag" waveform is maximally modulated
   D. "Cut" waveform has the lowest average current
      1. A, B & C only
      2. A and C only
      3. B and D only
      4. D only
      5. All of the above

45. Lateral thermal damage during bipolar electrosurgery can be minimized by:
   A. terminating on completion of the water vapor phase
   B. applying current in a pulsatile fashion
   C. irrigating the immediate surroundings
   D. applying current until abolished per an in-line ammeter
      1. A, B & C only
      2. A and C only
      3. B and D only
      4. D only
      5. All of the above
46. Tissue cutting with the ultrasonic laparoscopic cutting shears (LCS) is facilitated by:
   A. using greater blade excursion
   B. using a sharper blade
   C. squeezing tissue
   D. using a flattened surface
      1. A, B & C only
      2. A and C only
      3. B and D only
      4. D only
      5. All of the above

47. Which of the following statements about tissue fulguration are true?
   A. like electrosection, it is a noncontact electrosurgical technique
   B. it can be used efficiently to coagulate open bleeders in a wet field
   C. it requires a highly modulated waveform with high peak voltage
   D. it is the mechanism of action of argon-enhanced electrosurgery performed with the "cut" waveform
      1. A, B & C only
      2. A and C only
      3. B and D only
      4. D only
      5. All of the above
Pretest Questions Answer Key

1. B
2. A
3. C
4. A
5. B
6. C
7. A
8. B
9. C
10. D
11. 2
12. 3
13. 2
14. 1
15. 1
16. 4
17. 3
18. 3
19. 2
20. 5
21. 1
22. 2
23. 3
24. 1
25. 4
26. 2
27. 3
28. 1
29. 4
30. 6
31. 2
32. 4
33. 4
34. 1
35. 1
36. 4
37. 4
38. 4
39. 4
40. 3
41. 2
42. 5
43. 5
44. 1
45. 1
46. 1
47. 2