

Laparoscopic Hysterectomy

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Introduction & History

*"It is very dangerous to be right on a subject on which the established authorities are wrong."
- Voltaire*

Laparoscopic hysterectomy (LH), defined as the laparoscopic ligation of the major vessels supplying the uterus, is an alternative to abdominal hysterectomy with more attention to ureteral identification.¹⁻³ First performed in January, 1988⁴, laparoscopic hysterectomy stimulated a general interest in the laparoscopic approach to hysterectomy, as gynecologists not trained in vaginal or laparoscopic techniques struggled to maintain their fair share of the large lucrative hysterectomy market. A watered down version of LH, called laparoscopic assisted vaginal hysterectomy (LAVH), was taught and became known as an expensive and over-utilized procedure with indications for which skilled vaginal surgeons rarely found laparoscopic use necessary.

Today, there are few reasons for the expert laparoscopic or vaginal surgeon to perform an abdominal hysterectomy. Abdominal hysterectomy should be done less frequently, worldwide, because LH can be used effectively to accomplish a less invasive laparoscopic or vaginal hysterectomy in most cases. In the USA, 600,000 hysterectomies are performed each year. The problem is that in the United States, Britain, and in many other parts of the world, 70 percent of hysterectomies are still performed with mutilating abdominal incisions. This has not changed in the past 12 years despite the invention of LH. The only countries where more hysterectomies are performed without these incisions, for example laparoscopically or vaginally, are places like Taiwan or India where the doctors are reimbursed more if they perform a hysterectomy without a major incision.

In the United States, most gynecologists are trained to do abdominal hysterectomy. Then they go into a busy practice, usually as a junior partner, where they deliver babies for the next twenty years. Later, as their patients get older, they want to do some hysterectomies. Unfortunately, they don't go to back to school to learn the most efficacious way to perform a hysterectomy. They resort to the technique that they learned twenty years ago when they were residents -- which means a large, mutilating abdominal incision or, in some cases, a Pfannenstiel or a bikini cut. Both of these incisions cause more adhesions, pain and discomfort than if the operation were done with a laparoscope. Now we know that almost every case with an indication for hysterectomy can be done with a laparoscope.

In most specialties, innovative technology frequently separates a segment of the population into users and nonusers, and almost always the users have a clear advantage over the nonusers. This has been true with laparoscopic cholecystectomy, but not with LH.

Before 1988, laparoscopy was almost exclusively the domain of the gynecologist. It is ironic that though LH was introduced at the same time as laparoscopic cholecystectomy, it is performed on a much more minor scale worldwide. The rapid acceptance of laparoscopic cholecystectomy by surgeons did not occur with LH probably because most gynecologists are not surgeons.

Soon after the technique of laparoscopic cholecystectomy was published, it became clear that the procedure represented a significant advance in clinical surgery and was rapidly accepted. General surgeons who became proficient with the method learned that, compared with open

cholecystectomy, their patients were more comfortable postoperatively, required a shorter hospital stay, and experienced a more rapid convalescence and return to work and normal acts of daily living. Surgeons who did not learn the procedure found that few patients with gall bladder disease were referred to them, and many ceased performing operations on the biliary tract. Furthermore they did not have the basic skills necessary to learn the new laparoscopic procedures that were subsequently developed.

Today LH, a highly practical and useful technique also associated with more postoperative comfort, a shorter hospital stay, and a more rapid convalescence and return to work and normal acts of daily living, has not been widely adopted, primarily because many gynecologists have not exerted the effort to master it as they feel that they can function effectively with their current skills. Most women continue with the gynecologist who delivered their children for their gynecological operations. Contrary to the general surgeon's experience, the gynecologist does not feel any economic pressure to change even though it should be obvious that it is better for the patient.

Blame should not be placed entirely on the gynecologist. LH is also unpopular with hospital administration as it demands more OR time and, in inexperienced hands, expensive disposable instrumentation. This combination, in a managed care environment, can result in a net loss for the hospital. The insurance industry has also refused to compensate surgeons and hospitals with reasonable reimbursement for minimally invasive surgery performed on women. Poor reimbursement for the time of surgery and the time necessary to acquire the skill to do it discourages gynecologists and surgeons from mastering it. Certainly, women don't like large incisions and spend millions of dollars on plastic surgery to reduce or correct them.

True. New techniques must be properly assessed. Is it possible in most cases? Are the complications less if done by experts? Are patients generally satisfied? Is it cost effective (if done with reusable instruments)? The answer to all of these questions is a resounding "yes."

Laparoscopic Hysterectomy vs. Abdominal and Vaginal Hysterectomy

The first successful vaginal hysterectomy was performed by the "patient" in 1670, as reported by Percival Willouby. A 46-year old peasant named Faith Haworth was carrying a heavy load of coal when her uterus collapsed completely. Frustrated by this frequent occurrence, she grabbed her uterus, pulled as hard as possible, and cut the whole lot off with a short knife. The bleeding stopped and she lived on for many years, "water passing from her insensibly day and night" (personal communication from S. Joel-Cohen). Conrad Langenbeck performed the first planned vaginal hysterectomy in 1813.

Abdominal hysterectomy was first performed in 1843 by Clack, but the patient died of a pulmonary embolism. Walter Burnham performed the first successful abdominal hysterectomy in 1853, by accident. Upon opening the patient to remove a large ovarian cyst, she vomited, expelling a large fibroid uterus. As the surgeon was unable to put it back into the peritoneal cavity, he removed it supracervically. The first elective abdominal hysterectomy was by Clay and Koeberle in 1863.

Vaginal hysterectomy and abdominal hysterectomy techniques were progressively refined over the remainder of the nineteenth century, and by the early twentieth century had become established as the "classic" techniques, to be passed down essentially unaltered to successive generations of gynecologists.

Most gynecologists believe that they know the correct indications for performing vaginal hysterectomy and abdominal hysterectomy, but after more than 100 years of experience, there is still no consensus. Individual gynecologists may perform close to 100 percent of their hysterectomies by either "classic" route. Though Querleu, Kovac, Grody, and Stovall report more than 70 percent of their hysterectomies being performed vaginally, most data from around the world suggest that more than 70 percent of hysterectomies are abdominal, even in the absence of structural pathology.

Amazingly, vaginal hysterectomy and abdominal hysterectomy have never been subjected to a single class-**A** evidence study (randomized controlled trial), and have attracted very few comparative studies until the recent introduction of LH. Most studies were single-center retrospective -- covering many years (class **C**: personal series by experts).⁵ After a century of experience with the world's most commonly performed major operation, the gynecological profession as a whole still has no clear indication of the optimal method to perform hysterectomy in differing situations. It is accepted that abdominal hysterectomy can be used for every indication and can be considered the "default operation."

Into this foray came LH in 1988. LH stimulated a much greater interest in proper scientific evaluation of all forms of hysterectomy. From its invention, LH was considered a substitute for abdominal hysterectomy and not for vaginal hysterectomy. Yet unfavorable reports were published comparing LH to vaginal hysterectomy to further academic careers and hinder its acceptance in the US. Laparoscopic surgery has never been indicated for hysterectomy if the operation is feasible quickly and under good conditions via the vaginal route.

LH remains a reasonable substitute for abdominal hysterectomy. Most hysterectomies currently requiring an abdominal approach may be performed with laparoscopic dissection of part, or all, of the abdominal portion followed by vaginal removal of the specimen. Its use, however, has presently plateaued because most managed care plans reimburse the surgeon poorly for using a laparoscopic approach. Hospitals may benefit if they are reimbursed by DRG's paying the same amount for a 2-day hysterectomy stay as for 7 days but less if the hysterectomy patient is discharged within 24 hours (unbelievable). Unfortunately, some plans like Oxford reward the hospital for additional postoperative days, discouraging both hospital administrator and surgeon from encouraging short hospital-stay laparoscopic surgery over traditional laparotomy.

Surgical Advantages

There are many surgical advantages to laparoscopy, particularly magnification of anatomy and pathology, easy access to the vagina and rectum, and the ability to achieve complete hemostasis and clot evacuation during underwater examination. Patient advantages are multiple and are related to avoidance of a painful abdominal incision. They include reduced duration of hospitalization and recuperation and an extremely low rate of infection and ileus.

The goal of vaginal hysterectomy, LAVH, or LH is to safely avoid an abdominal wall incision, with resultant benefits just described. The surgeon must remember that if he/she is more comfortable with vaginal hysterectomy after ligating the ovarian ligaments, this should be done. Laparoscopic inspection at the end of the procedure will still permit the surgeon to control any bleeding and evacuate clots, and laparoscopic cuff suspension should limit future cuff prolapse. Unnecessary surgical procedures should not be done because of the surgeon's preoccupation with the development of new surgical skills. I emphasize, a laparoscopic hysterectomy is not indicated when vaginal hysterectomy can be easily and safely done.

Laparoscopy Glossary

There are a variety of operations where the laparoscope is used as an aid to hysterectomy (Table 1). It is important that these different procedures are clearly delineated:

- **Diagnostic Laparoscopy With Vaginal Hysterectomy**
Indicates that the laparoscope is used for diagnostic purposes to determine if vaginal hysterectomy is possible when indications for a vaginal approach are equivocal. It also assures that the vaginal cuff and pedicle hemostasis is complete and allows clot evacuation.
- **Laparoscopic Assisted Vaginal Hysterectomy (LAVH)**
A vaginal hysterectomy after laparoscopic adhesiolysis, endometriosis excision or oophorectomy. Unfortunately, this term is also used when the upper uterine ligaments (for example, round, infundibulopelvic or uteroovarian ligaments) of a relatively normal uterus are ligated with staples or bipolar desiccation. It must be emphasized that in most small uterus cases, the easy part of both an abdominal or vaginal hysterectomy is upper pedicle ligation.
- **Laparoscopic Hysterectomy (LH)**
Denotes laparoscopic ligation of the uterine arteries either by electrosurgery desiccation, suture ligation, or staples.⁴ All surgical steps after the uterine vessels have been ligated can be performed either vaginally or laparoscopically, including anterior and posterior vaginal entry by transection, cardinal and uterosacral ligament division, uterine removal (intact or by morcellation), and vaginal closure (vertically or transversely). Laparoscopic ligation of the uterine vessels is the sine qua non for laparoscopic hysterectomy. Ureteral identification often by isolation has always been advised.
- **Total Laparoscopic Hysterectomy (TLH)**
The laparoscopic dissection continues until the uterus lies free of all attachments in the peritoneal cavity. The uterus is then removed through the vagina, with morcellation if necessary. The vagina is closed with laparoscopically placed sutures. No vaginal surgery is done unless morcellation is necessary.⁶

NOTE: I use the term "laparoscopic hysterectomy" to include all types of cases using the laparoscope. LAVH is just one type and is really a vaginal hysterectomy (almost all LAVH's can be done as completely vaginal hysterectomies; TLH implies that a vaginal hysterectomy would be difficult or impossible to perform, i.e., TLH is a substitute for abdominal hysterectomy, not for vaginal hysterectomy.)
- **Laparoscopic Supracervical Hysterectomy (LSH)**
Recently regained some support after suggestions that it offers physicians a less risky procedure than total hysterectomy performed through the laparoscope with decreased risk of dissection of the ureter and main division of the uterine artery. The uterus is removed by morcellation from above or below.⁷
- **Hysterectomy** means removal of the uterus. Is the cervix a part of the uterus or not? If the cervix is left, better names would be **partial hysterectomy**, **subtotal hysterectomy**, or **fundectomy**, as these terms denote that the uterus was not completely removed. (Speculations regarding the cervical orgasm issue are groundless as there are no data. There are very few women who report a decrease in orgasmic ability with removal of the

cervix.^{8,9} The other theory regarding the supracervical approach is that it is less likely to lead to future vault prolapse because of the preservation of the pelvic floor supports, with the cardinal and uterosacral ligaments remaining intact. Certainly, if the uterosacral-cardinal complex is attached to the upper vagina instead of the sides of the cervix and the endopelvic fascia is brought together with underlying vagina across the midline, support should be better than before the operation.

- Kurt Semm's version of a supracervical hysterectomy, often referred to as the CISH procedure (Classical Interstitial Semm Hysterectomy), leaves the cardinal ligaments intact while eliminating the columnar cells of the endocervical canal. After perforating the uterine fundus with a long sound-dilator, a calibrated uterine resection tool (CURT) that fits around this instrument is used to core out the endocervical canal. Thereafter, at laparoscopy, suture techniques are used to ligate the utero-ovarian ligaments. An Endoloop is placed around the uterine fundus to the level of the internal os of the cervix and tied. The uterus is divided at its junction with the cervix and removed by laparoscopic morcellation.¹⁰
- **Laparoscopic Pelvic Reconstruction (LPR) with Vaginal Hysterectomy**
Useful when vaginal hysterectomy alone cannot accomplish appropriate repair for vaginal prolapse. Ureteral dissection and suture placement through the uterosacral ligaments near the sacrum, before the vaginal portion of the procedure, may be useful to achieve vaginal suspension (see below). Levator muscle plication vaginally or laparoscopically is often necessary. Retropubic Burch colposuspension can also be done laparoscopically.

Indications

Indications for laparoscopic hysterectomy include:

- **Symptomatic Uterine Fibroids (hypermenorrhea, pelvic pressure, and rarely pain).**
Almost all of these cases can be performed laparoscopically as an outpatient, or during a 1-to-2-day hospital stay. Morcellation is often necessary and is done laparoscopically and/or vaginally using a scalpel. Fibroids fixed in the pelvis or abdomen without descent are easier to mobilize laparoscopically. For the surgeon, it is important to obtain current uterine size and weight measurements to confirm the appropriateness of the laparoscopic hysterectomy, since most small uteri can be removed vaginally. For example, the normal uterus weighs 70-125 g, a 12-week gestational age uterus weighs 280-320 g, a 24-weeks uterus weighs 580-620 g, and a term uterus weighs 1,000-1,100 g.
- **Endometriosis.**
Endometriosis can involve the uterus and the areas around the uterus. Very commonly the endometriosis will grow in the posterior cervix and cause very painful periods and, in some people, pain all day, every day. In all these cases, the endometriosis should be removed. Hysterectomy should not be done for stage IV endometriosis with extensive cul-de-sac involvement, unless the surgeon has the skill and time to resect all deep fibrotic endometriosis from the posterior vagina, uterosacral ligaments, and anterior rectum, and only then a hysterectomy to remove possible deep intrauterine endometriosis, which is called adenomyosis.

Unfortunately, hysterectomy is commonly done using an intrafascial technique which leaves the deep fibrotic endometriosis behind to cause future problems. Later, when pain persists, it becomes much more difficult to remove deep fibrotic endometriosis when

there is no uterus between the anterior rectum and the bladder. After hysterectomy, the endometriosis left in the anterior rectum and vaginal cuff frequently becomes densely adherent to, or invades into, the bladder and one or both ureters. In many patients with stage IV endometriosis and extensive cul-de-sac obliteration, it is preferable to preserve the uterus and prevent future vaginal cuff, bladder, and ureteral problems.¹⁴ Obviously, this approach will not be effective when uterine adenomyosis is present. In these cases, after excision of cul-de-sac endometriosis, persistent pain will ultimately require a hysterectomy. Oophorectomy is not usually necessary at hysterectomy for advanced endometriosis, if the endometriosis is carefully removed. Re-operation for recurrent symptoms is necessary in less than 5 percent of my patients in whom one or both ovaries have been preserved. Bilateral oophorectomy is rarely indicated in women under age 40 undergoing hysterectomy for endometriosis.

- **Benign Pathology**
Endometriosis, fibroids, adhesions, and adnexal masses usually requiring the selection of an abdominal approach to hysterectomy.
- **Obese Women**
Laparoscopic procedures allow the surgeon to make an incision above the panniculus.
- **Stage I Endometrial, Ovarian and Cervical Cancer Cases.**¹¹⁻¹³
- **Pelvic Reconstruction procedures**
Including cuff suspension, retropubic colposuspension, and rectocele repair may be simultaneously accomplished through the laparoscope.
- When vaginal hysterectomy is not possible because of a narrow pubic arch, a constricted vagina with no prolapse, or severe arthritis that prohibits placement of the patient in sufficient lithotomy position for vaginal exposure.
- **Abnormal Uterine Bleeding**
Hysterectomy may be performed in women of reproductive age. Abnormal uterine bleeding is defined as excessive uterine bleeding, or irregular uterine bleeding, for more than eight days during more than a single cycle or as profuse bleeding requiring additional protection (large clots, gushes, or limitations on activity). There should be no history of a bleeding diathesis or use of medication that may cause bleeding. A negative effect on quality of life should be documented. Physical examination, laboratory data, ultrasound, and hysteroscopy are frequently negative. Hormonal or other medical treatment should be attempted before hysterectomy, and its failure, contraindication, or refusal should be documented. The presence of anemia is recorded and correction with iron supplementation attempted. If hysterectomy is chosen, a vaginal approach is usually appropriate. Laparoscopic hysterectomy is done only when vaginal hysterectomy is not feasible, including history of previous abdominal surgery and lack of prolapse (nulliparous or multiparous). TLH is considered if the surgeon has little experience with the vaginal approach.

Contraindications

LH is not advised for the diagnosis and treatment of a pelvic mass that cannot be removed intact through a culdotomy incision or that is too large to fit intact into an impermeable sack, particularly in postmenopausal patients. The largest available sack for removal of intraperitoneal masses is the LapSac (Cook Ob/Gyn, Spencer, IN), which measures 11 x 8 inches. While cyst aspiration is advocated by some investigators,^{15,16} I feel that postmenopausal cystic ovaries should not be subjected to aspiration before oophorectomy because the inevitable spillage may change the diagnosis from a stage Ia ovarian cancer to a stage Ic. Its effect on survival is unknown, but it

may be detrimental. It must be emphasized that aspiration through a small gauge needle placed through a thickened portion of the ovary and cyst aspiration devices with surrounding suction and endoloop placement (Cook) do not completely prevent spillage.

A history of extensive abdominal adhesions should not necessitate a laparotomy; remember that previous laparotomies are probably what caused the adhesions in the first place. The patient should be referred to an expert laparoscopic surgeon.

The medical status of the patient may prohibit surgery. Anemia, diabetes, lung disorders, cardiac disease, and bleeding diathesis should be excluded prior to surgery. Age alone should rarely be a deterrent.

The need for peripartum hysterectomy for placenta accreta, uterine atony, unspecified uterine bleeding, and uterine rupture are relative contraindications at present. However, laparoscopic hysterectomy may be considered for patients needing a postpartum hysterectomy.

Another contraindication is stage III ovarian cancer that requires a large abdominal incision. Finally, inexperience or inadequate training of the surgeon is a contraindication to the laparoscopic approach.

Equipment

Operating room tables capable of 30° Trendelenburg's position are extremely valuable for laparoscopic hysterectomy. Unfortunately these tables are rare, and this author has much difficulty operating when only a limited degree of body tilt can be attained. For the past 18 years steep Trendelenburg's position (20°-40°), with shoulder braces and the arms at the patient's sides, has been used without adverse effects.

A Valtchev uterine mobilizer (Conkin Surgical Instruments, Toronto, ON) is the best available single instrument to antevert the uterus and delineate the posterior vagina.¹⁷ With this instrument, the uterus can be anteverted to about 120° and moved in an arc about 45° from the horizontal by turning the mobilizer around its longitudinal axis. Either the 100 mm long and 10 mm thick, or the 80 mm long and 8 mm thick, obturator may be used for uterine manipulation during hysterectomy. Placement of a #81 French rectal probe (Reznik Instruments, Skokie, IL) and intraoperative rectovaginal examinations remain important techniques for defining the rectovaginal space, even when the Valtchev uterine mobilizer is available whenever rectal location is in doubt.

Trocar sleeves are available in many sizes and shapes. For most cases, 5.5 mm diameter cannulas are adequate. Short trapless 5 mm trocar sleeves with a retention screw grid around the external surface (reusable: Richard Wolf Medical Instruments, Vernon Hills, IL; disposable: Apple Medical, Bolton, MA) are used to facilitate efficient instrument exchanges and evacuation of tissue while allowing unlimited freedom during extracorporeal suture tying.¹⁸ With practice, a good laparoscopic surgical team will be able to make instrument exchanges fast enough so that little pneumoperitoneum is lost.

Self-retaining lateral vaginal wall retractors or Vienna retractors (Brisky-Navatril) are used for vaginal extraction of a large fibroid uterus without changing stirrups. Alternatively, after the

abdominal portion of the procedure is completed, the stirrups are replaced with candy-cane stirrups to obtain better hip flexion, so that conventional vaginal sidewall retractors can be used.

Monopolar cutting current through electrosurgical electrodes that eliminate capacitance and insulation failures (Electroshield from Electroscope, Boulder, CO) is used. Bipolar forceps with high-frequency low-voltage cutting current (20-50 W) can coagulate vessels as large as the ovarian and uterine arteries. The Kleppinger bipolar forceps (Richard Wolf) are excellent for large vessel hemostasis. Microbipolar forceps contain a channel for irrigation and a fixed distance between the electrodes. Irrigation is used to identify bleeding sites before coagulation and to prevent sticking of the electrode to the eschar that is created. Irrigation is also used during underwater examination to dilute blood products surrounding a bleeding vessel so that it may be identified before coagulation. Disposable stapling instruments are rarely used for laparoscopic hysterectomy because of their expense. Suture and/or bipolar desiccation work better.

Preoperative Preparation

Surgical skill remains paramount. Ambidexterity separates the laparoscopic surgeon from those trained traditionally, as the surgeon must often hold the camera with the dominant hand.

The patient is optimized medically for coexistent problems. Patients are encouraged to hydrate and eat lightly for 24 hours before admission on the day of surgery. Fleets Phospho-soda prep kit #3 is administered the day before surgery to evacuate the lower bowel as follows: First Fleet Phospho Soda mixed into a half glass of cool clear juice in the late afternoon, then 4 Bisacodyl tablets in the early evening, and finally a Fleet Bisacodyl enema 1-2 hours before bedtime (10 mg). Lower abdominal, pubic, and perineal hair is not shaved. Antibiotics (usually cefoxitin or cefotetan) are administered preoperatively in all cases. A Foley catheter is inserted during surgery and removed in the recovery room or the next morning.

Positioning of the patient

All laparoscopic surgical procedures are done under general anesthesia with endotracheal intubation. The routine use of an orogastric tube is recommended to diminish the possibility of a trocar injury to a gas filled stomach and to reduce small bowel distension during the operation. The patient remains flat (0°) on the operating table until the umbilical trocar sleeve has been inserted and then is placed in steep Trendelenburg's position (20°-30°). Lithotomy position with the hip extended (thigh parallel to abdomen) is obtained with Allan stirrups (Edgewater Medical Systems, Mayfield Heights, OH) or knee braces, that are adjusted for each individual patient before anesthesia. Examination under anesthesia is always performed prior to prepping the patient.

Laparoscopy was never thought to be a sterile procedure before the incorporation of video, as the surgeon operated with his head in the surgical field, attached to the laparoscopic optic. Furthermore, it is not possible to sterilize skin. Since 1983, I have maintained a policy of not scrubbing and not sterilizing or draping the camera or laser arm. Masking is optional. (Most surgeons in the United Kingdom don't mask for laparoscopic surgery.) Infection has been rare: less than one %. The vertical intraumbilical umbilical incision is closed with a single 4-0 Vicryl suture opposing deep fascia and skin dermis, with the knot buried beneath the fascia. This will prevent the suture from acting like a wick transmitting bacteria into the soft tissue or peritoneal

cavity. The lower quadrant incisions are loosely approximated with a Javid vascular clamp (V. Mueller, McGaw Park, IL) and covered with Dermabond (Ethicon) or Collodion (AMEND, Irvington, NJ) to allow drainage of excess Ringer's lactate solution.

Total Laparoscopic Hysterectomy Technique (TLH)

My technique for a TLH is described, since other types of laparoscopic hysterectomy (e.g. LAVH or LH) are simply modifications of this more extensive procedure.

Incisions and Vaginal preparation

Three laparoscopic puncture sites including the umbilicus are used: 10 umbilical, 5 mm right, and 5 mm left lower quadrant. The left lower quadrant puncture is the major portal for operative manipulation. The right trocar sleeve is used for retraction with atraumatic grasping forceps.

A recent study documented that most women prefer the cosmetic appearance of a 15 cm Pfannenstiel incision to multiple 12 mm high incisions required for stapling devices. Reduction in wound morbidity and scar integrity as well as cosmesis are enhanced using 5 mm sites.¹⁹ The use of 12 mm incisions when a 5 mm one will suffice is not an advance in minimally invasive surgery.

The endocervical canal is dilated to Pratt #25, and the Valtchev uterine mobilizer with blunt tip (Conkin Surgical Instruments, Toronto, Canada) is inserted to antevert the uterus and delineate the posterior vagina. When the uterus is in the anteverted position, the cervix sits on a wide pedestal, making the vagina readily visible between the uterosacral ligaments when the cul-de-sac is viewed laparoscopically.

Exploration

The upper abdomen is inspected, and the appendix is identified. If appendiceal pathology is present, i.e., dilatation, adhesions, or endometriosis, appendectomy is done by mobilizing the appendix, isolating its blood supply by making a window in the mesoappendix near the cecum with reusable Metzenbaum-type scissors, passing a 2/0 Vicryl free ligature through this window, and securing it extracorporeally with the Clarke-Reich knotpusher. Three Endoloops [Endoloop (chromic gut ligature), Ethicon, Somerville, NJ] are then placed at the appendiceal-cecal junction after desiccating the appendix just above this juncture. The appendix is left attached to the cecum; its stump is divided later in the procedure, after opening the cul-de-sac, so that removal from the peritoneal cavity is accomplished immediately after separation.

Ureteral Dissection

Three approaches have been used for laparoscopic ureteric identification, which may be called medial, superior, and lateral. Stents are not used as they cause hematuria and ureteric spasm in some patients. When the ureter is identified but not dissected, cystoscopy is done after vaginal closure to check for ureteral patency, 5 minutes after one ampoule of Indigo Carmine dye is administered intravenously. The laparoscopic surgeon should dissect (skeletonize) either the ureter or the uterine vessels during the performance of a laparoscopic hysterectomy.

The medial approach (Reich)

If the uterus is anteflexed, the ureter can usually be easily visualized in its natural position on the medial leaf of the broad ligament provided there is no significant cul-de-sac or adnexal pathology. This allows the peritoneum immediately above the ureter to be incised to create a "window" in the peritoneum, which makes for safe division of the infundibulopelvic ligament or adnexal pedicle. Immediately after exploration of the upper abdomen and pelvis, each ureter is isolated deep in the pelvis, when possible. Ureteral dissection is performed early in the operation before the pelvic sidewall peritoneum becomes edematous and/or opaque from irritation by the CO₂ pneumoperitoneum or aquadissection and before ureteral peristalsis is inhibited by surgical stress, pressure, or the Trendelenburg's position.¹

The ureter and its overlying peritoneum are grasped deep in the pelvis. An atraumatic grasping forceps is used from the opposite sided cannula to grab the ureter and its overlying peritoneum on the pelvic sidewall below and caudad to the ovary, lateral to the uterosacral ligament. Scissors are used to divide the peritoneum overlying the ureter and are inserted into the defect created and spread. Thereafter one blade of the scissors is placed on top of the ureter, its blade visualized through the peritoneum, and the peritoneum divided. This is continued into the deep pelvis where the uterine vessels cross the ureter, lateral to the cardinal ligament insertion into the cervix. Connective tissue between the ureter and the vessels is separated with scissors. Bleeding is controlled with microbipolar forceps. Often the uterine artery is ligated at this time to diminish backbleeding from the upper pedicles.

The superior approach

The superior approach entails dissecting the colon (rectosigmoid on the left; caecum on the right) off of the pelvic brim and freeing the infundibulopelvic ligament vessels from the roof of the broad ligament to allow the ureter that lies below it to be identified. The ureter is then reflected off the broad ligament and traced into the pelvis.

The lateral approach (Kadar)

The lateral approach makes use of the pararectal space to identify the ureter, and the ureter does not have to be peeled off the broad ligament for its entire pelvic course to be visible. The tip of the laparoscope is often the best blunt dissector in this area and may be inserted alongside and just lateral to the pelvic sidewall peritoneum into the loose areolar tissue already distended by retroperitoneal CO₂ until ureter and uterine vessels are identified.

By displacing the uterus to the contralateral side, a pelvic sidewall triangle is identified formed by the round ligament, the lateral border by the external iliac artery, and the medial border by the infundibulopelvic ligament. The peritoneum in the middle of the triangle is incised with scissors and the broad ligament opened by bluntly separating the extraperitoneal areolar tissues. The infundibulopelvic ligament is pulled medially with grasping forceps to expose the ureter at the pelvic brim where it crosses the common or external iliac artery.²⁰

The operator then searches for the ureter distal to the pelvic brim and lateral to the infundibulopelvic ligament. The dissection is carried bluntly underneath and caudad to the round ligament, until the obliterated hypogastric artery is identified extraperitoneally. If any difficulty is encountered, the artery is first identified intraperitoneally where it hangs from the anterior abdominal wall, traced proximally to where it passes behind the round ligament, and then with

both its intraperitoneal portion and the dissected space under the round ligament in view, the intraperitoneal part of the ligament is moved back and forth. Once the obliterated hypogastric artery has been identified extraperitoneally it is an easy matter to develop the paravesical space by bluntly separating the areolar tissue on either side of the artery. The obliterated hypogastric artery is next traced proximally to where it is joined by the uterine artery, and the pararectal space opened by blunt dissection proximal and medial to the uterine vessels, which lie on top of the cardinal ligament. Once the pararectal space has been opened, the ureter is easily identified on the medial leaf of the broad ligament, which forms the medial border of the pararectal space. The uterine artery and cardinal ligament at the distal (caudal) border of the space, and the internal iliac artery on its lateral border also become clearly visible.

Retroperitoneal dissection

At the start of most laparoscopic hysterectomies, the anterior broad ligament is stretched out by pulling the fallopian tube medially and scissors are used to make an incision in it behind the round ligament for oophorectomy and in front of the round ligament for ovarian preservation. CO₂ from the pneumoperitoneum rushes into the retroperitoneum and distends it. The tip of the laparoscope is then used to perform "optical dissection" of the retroperitoneal space behind the uterus for oophorectomy and parallel to it for ovarian preservation.

Bladder mobilization

The round ligaments are divided at their midportion using a spoon electrode (Electroscope) set at 150 W cutting current. Persistent bleeding is controlled with bipolar desiccation at 30 W cutting current. Thereafter scissors or the same electrode are used to divide the vesicouterine peritoneal fold starting at the left side and continuing across the midline to the right round ligament. The upper junction of the vesicouterine fold is identified as a white line firmly attached to the uterus, with 2-3 cm between it and the bladder dome. The initial incision is made below the white line while lifting the peritoneum covering the bladder. The bladder is mobilized off the uterus and upper vagina using scissors or bluntly with the same spoon electrode or a suction-irrigator until the anterior vagina is identified by elevating it from below with ring forceps.

Upper uterine blood supply

When ovarian preservation is desired, the utero-ovarian ligament and fallopian tube pedicles are suture-ligated adjacent to the uterus with 2/0-Vicryl, using either a curved needle or a free ligature passed through a window created around the ligament. To create the window, the peritoneum is opened just lateral to the tubal cornua, and the Metzenbaum type scissors slid down lateral to the uteroovarian vessels until its tip can be seen through the broad ligament peritoneum which is divided. Alternatively, the utero-ovarian ligament and fallopian tube may be coagulated until desiccated with bipolar forceps, at 25-35 W cutting current, and then divided.

When oophorectomy is indicated or ovarian preservation not desired, the anterior and posterior leaves of the broad ligament are opened lateral and below the infundibulopelvic ligament with a laparoscopic Metzenbaum type scissors and a 2/0-Vicryl free ligature passed through the window thus created and tied extracorporeally using the Clarke-Reich knotpusher.²¹ This is repeated twice around the ovarian vessels so that two proximal ties and one distal one are placed, and the ligament then divided. I rarely desiccate the infundibulopelvic ligament today as it results in too

much smoke early in the operation. While applying traction to the cut distal pedicle, the broad ligament is divided to the round ligament just lateral to the uteroovarian artery anastomosis using cutting current through a spoon electrode.

If suturing skills are not developed and the tube and ovary are to be removed, the infundibulopelvic ligament is mobilized and Kleppinger bipolar forceps (Richard Wolf Medical Instruments, Vernon Hills, IL) are used to compress and desiccate its vessels or the MULTIFIRE ENDO GIA 30 (U.S. Surgical, Norwalk, CT) applied. The round ligament is desiccated and divided. If the ovary is to be preserved, the utero-ovarian ligament/round ligament/Fallopian tube junction may be divided with the ENDO GIA stapler. This may be time saving for this portion of the procedure, thus justifying its increased cost.

Uterine vessel ligation

The uterine vessels may be ligated at their origin, at the site where they cross the ureter, or on the uterus.

In most cases, the uterine vessels are suture ligated as they ascend the sides of the uterus. The broad ligament on each side is skeletonized down to the uterine vessels. Each uterine vessel pedicle is suture-ligated with 0-Vicryl on a CTB-1 blunt needle (Ethicon JB260) (27").⁶ The needles are introduced into the peritoneal cavity by pulling them through a 5 mm incision.²² The curved needle is placed around the uterine vessel pedicle at the side of the uterus. A short rotary movement of the Cook oblique curved needle holder brings the needle around the uterine vessel pedicle. The uterine artery is a sturdy structure and can be grasped and elevated carefully to avoid the uterine veins underneath. In some cases, the vessels can be completely skeletonized and a 2-0 Vicryl free suture ligature passed around them. Sutures are tied extracorporeally using a Clarke-Reich knot pusher.²¹

In some cases the curved needle is inserted on top of the unroofed ureter where it turns medially towards the previously mobilized bladder. A single suture placed in this manner on each side serves as a "sentinel stitch," identifying the ureter for the remainder of the procedure.

Division of cervicovaginal attachments and circumferential culdotomy

The cardinal ligaments on each side are divided with the CO2 laser at high power (80 W) or with the spoon electrode at 150 W cutting current. Bipolar forceps are used to coagulate the uterosacral ligaments and are invaluable to control bleeding from vaginal branches. The vagina is entered posteriorly over the Valtchev retractor near the cervicovaginal junction. A 4 cm diameter vaginal delineator (R. Wolf) is placed in the vagina to outline circumferentially the cervicovaginal junction, serve as a backstop for laser work, and prevent loss of pneumoperitoneum. First, it identifies the anterior cervicovaginal junction and then the lateral fornices. They are incised using the laser with the delineator as a back stop to complete the circumferential culdotomy. The uterus is morcellated, if necessary, and pulled out of the vagina.

When the vaginal delineator is not available, a ring forceps is inserted into the anterior vagina above the tenaculum on the anterior cervical lip to identify the anterior cervicovaginal junction. The left anterior vaginal fornix is entered using the laser, so that the aquapurator can be inserted into the anterior vagina above the anterior cervical lip. Following the aquapurator tip or ring forceps, and using them as a backstop, the anterior and lateral vaginal fornices are divided. The

aquapurator is inserted from posterior to anterior to delineate the right vaginal fornix which is divided. The uterus can then be pulled out of the vagina.

Morcellation (Laparoscopic and Vaginal)

Morcellation can be done laparoscopically or vaginally. For the laparoscopic technique, a #10 blade on a long handle is introduced gently through the left 5-mm trocar incision after removing the trocar. With care the uterus and its enclosed large myoma can be bivalved with the blade. The surgeon's fingers in contact with the skin prevent loss of pneumoperitoneum.

Vaginal morcellation is done in most cases on a uterus free in the peritoneal cavity but may be considered after securing the ovarian arteries from above and the uterine arteries from above or below. A #10 blade on a long knife handle is used to make a circumferential incision into the fundus of the uterus while pulling outwards on the cervix and using the cervix as a fulcrum. The myometrium is incised circumferentially parallel to the axis of the uterine cavity with the scalpel's tip always inside the myomatous tissue and pointed centrally, away from the surrounding vagina. The knife is not extended through the serosa of the uterus. The incision is continued around the full circumference of the myometrium in a symmetrical fashion beneath the uterine serosa. Traction is maintained on the cervix, and the avascular myometrium is cut so that the endometrial cavity with a surrounding thick layer of myometrium is delivered with the cervix, bringing the outside of the uterus closer to the operator for further excision by wedge morcellation.

Wedge morcellation is done by removing wedges of myoma and myometrium from the anterior and posterior uterine wall, usually in the midline, to reduce the bulk of the uterus. After excision of a large core, the fundus is morcellated with multiple wedge resections, around either a tenaculum or an 11-mm corkscrew (WISAP, Sauerlach, Germany). The remaining fundus, if still too large for removal, can be bivalved so that one half can be pulled out of the peritoneal cavity, followed by the other half.

Morcellation of fibroids through anterior abdominal wall puncture sites is now practical when vaginal access is limited. The Steiner Electromechanical Morcellator (Karl Storz, Tuttlingen, Germany) is a 10-mm diameter motorized circular saw that uses claw forceps or a tenaculum to grasp the fibroid and pull it into contact with the fibroid. Large pieces of myomatous tissue are removed piecemeal until the myoma can be pulled out through the trocar incision. With practice this instrument can often be inserted through a stretched 5-mm incision without an accompanying trocar.

Laparoscopic vaginal vault closure and suspension with McCall culdeplasty

The vaginal delineator or a sponge in a glove pack is placed back into the vagina for closure of the vaginal cuff, occluding it to maintain pneumoperitoneum. The uterosacral ligaments are identified by bipolar desiccation markings or with the aid of a rectal probe. The left uterosacral ligament is elevated and a 0-Vicryl suture on a CT-1 needle is placed through it using an oblique Cook needle holder, then through the left cardinal ligament with just a few cells of posterolateral vagina just below the uterine vessels, and along the posterior vaginal epithelium with a few bites over to the right side. Finally, the same suture with needle is used to fix the right posterolateral vagina and cardinal ligament to the right uterosacral ligament.

This suture is tied extracorporeally and provides excellent support to the vaginal cuff apex, elevating it superiorly and posteriorly toward the hollow of the sacrum. The rest of the vagina and the overlying pubocervicovesicular fascia are closed vertically with one or two 0-Vicryl interrupted sutures. In most cases the peritoneum is not closed.

Cystoscopy

Cystoscopy is done after vaginal closure to check for ureteral patency, 10 minutes after intravenous administration of one ampoule of Indigo Carmine dye. This is especially necessary when the ureter is identified but not dissected. Blue dye should be visualized through both ureteral orifices. The bladder wall should also be inspected for suture and thermal defects.²³

Underwater examination

At the close of each operation, an underwater examination is used to detect bleeding from vessels and viscera tamponaded during the procedure by the increased intraperitoneal pressure of the CO₂ pneumoperitoneum. The CO₂ pneumoperitoneum is displaced with 2-5 L of Ringer's lactate solution, and the peritoneal cavity is vigorously irrigated and suctioned until the effluent is clear of blood products. Any further bleeding is controlled underwater using microbipolar forceps to coagulate through the electrolyte solution, and at least 2 L of lactated Ringer's solution are left in the peritoneal cavity.

SPECIAL PROBLEMS RELATED TO LAPAROSCOPIC HYSTERECTOMY

My most recent technique involves isolation and ligation of the uterine artery on the side of the uterus early in the operation to limit backbleeding from the uteroovarian ligament, especially if ovarian preservation is desired. The round ligament incision is extended into the ipsilateral portion of the vesicouterine peritoneal fold, and the pulsating uterine artery identified and ligated either with a CT-1 needle or a free ligature. In these cases, the ureter is not isolated because the uterine vessels on the side of the uterus are usually well above them; cystoscopy is done after cuff closure, 10 minutes after indigo carmine dye administration.

Endometriosis nodules in the muscularis of the anterior rectum can usually be excised laparoscopically. Full-thickness penetration of the rectum can occur during hysterectomy surgery, especially when excising rectal endometriosis nodules. Following identification of the nodule or rent in the rectum, a closed circular stapler [Proximate ILS Curved Intraluminal Stapler (Ethicon, Stealth)] is inserted into the lumen just past the lesion or hole, opened 1-2 cm, and held high to avoid the posterior rectal wall. The proximal anvil is positioned just beyond the lesion or hole which is invaginated into the opening and the device closed. Circumferential inspection is made to insure the absence of encroachment of nearby organs and posterior rectum in the staple line and the lack of tension in the anastomosis. The instrument is fired, then removed through the anus. The surgeon must inspect and insure that the fibrotic lesion or a donut of tissue representing the excised hole is contained in the circular stapler. Once verified, anastomotic inspection is done laparoscopically underwater after filling the rectum with indigocarmine solution.

POSTOPERATIVE CONSIDERATIONS

Postoperatively, the vaginal cuff is checked for granulation tissue between six and 12 weeks, as sutures are usually absorbed by then and healing should be complete. Routine checks at 1-4 weeks are usually not indicated as a pelvic examination could impede healing. Examinations usually within 1 week are indicated for pain, pressure, or pyrexia. Patients usually experience some fatigue and discomfort for approximately 2-4 weeks after the operation, but may perform

gentle exercise such as walking and return to routine activities between two and six weeks. Sexual activity may be resumed when the vaginal incision has healed, usually after six weeks.

COMPLICATIONS

Complications of laparoscopic hysterectomy are those of hysterectomy and laparoscopy: anesthetic accidents, respiratory compromise, thromboembolic phenomenon, urinary retention, injury to vessels, ureters, bladder, and bowel, and infections, especially of the vaginal cuff.²⁴⁻²⁸ Ureteral injury is more common when staplers or bipolar desiccation are used without ureteral identification. Complications unique to laparoscopy include large vessel injury, epigastric vessel laceration, subcutaneous emphysema, and trocar site incisional hernias.²⁹

Since the introduction of prophylactic antibiotics, vaginal cuff abscess, pelvic thrombophlebitis, septicemia, pelvic cellulitis, and adnexal abscesses are rare. Abdominal wound infection is rare.

INFECTION

Febrile morbidity associated with a vaginal hysterectomy is about half that of the abdominal procedure. Laparoscopic evacuation of all blood clots and the sealing of all blood vessels after the uterus has been removed should reduce further the infection rate. Morcellation during laparoscopic or vaginal hysterectomy results in a slightly increased risk of fever, especially if prophylactic antibiotics are not used.

Since the introduction of prophylactic antibiotics, vaginal cuff infection is rare. This infection can result in pelvic cellulitis, septicemia, vaginal cuff abscess, adnexal abscesses, and pelvic thrombophlebitis. Abdominal trocar wound infection is also rare.

This author has experience with only two cases of pelvic cellulitis and three pelvic abscesses in over 400 laparoscopic hysterectomies. The average surgical time was over three hours in this high degree of difficulty population of extensive endometriosis and large uterus cases. My first year at Columbia Presbyterian Medical Center, my 27 cases averaged 650 grams and involved extended morcellation.

The pelvic cellulitis cases presented with spiking pyrexia and pelvic pain and tenderness approximately one week postoperatively. Ultrasound examination was negative for a collection. They both responded to in hospital intravenous antibiotics and one required multiple cuff treatments with silver nitrate sticks. All of the three abscess patients were treated during hospital readmission, and none responded to vaginal cuff drainage. One of the pelvic abscesses was treated by laparoscopic drainage 16 days after her original surgery, another by ultrasound guided aspiration with insertion of a drainage tube, and the third underwent laparotomy drainage 10 days postoperatively at a distant hospital after attempted vaginal drainage resulted in heavy bleeding. One other patient whose original hysterectomy surgery involved a pelvic abscess required rehospitalization.

I use one dose of a prophylactic antibiotics after induction of anesthesia in all cases. Interestingly, no antibiotic was administered in four of the above described five cases of infection. All of these cases involved a return to hospital and much patient dissatisfaction. I did not have any success with outpatient management that usually accompanies vaginal drainage after a vaginal hysterectomy.

To decrease postoperative infection, the surgeon should evacuate all large clots, obtain absolute hemostasis, and then do copious irrigation to dilute fibrin and prostaglandins arising from operated surfaces and bacteria. I believe that leaving at least two L of lactated Ringer's solution in the peritoneal cavity dilutes the peritoneal cavity bacterial and blood product counts and prevents fibrin adherences from forming by separating raw compromised surfaces during the initial stages of reperitonealization, especially after hysterectomy or bowel resection. No other anti-adhesive agents are employed. No drains, antibiotic solutions, or heparin are used.

I have no experience with a serious wound infection after laparoscopic hysterectomy. I suspect this is because I rarely use more than two 5-mm lower trocar incisions, and I do not use suture to close them. The umbilical incision is placed vertically deep in the umbilicus where skin, deep fascia, and parietal peritoneum meet. This umbilical incision is closed with a single 4-0 Vicryl suture opposing deep fascia and skin dermis. The knot is buried beneath the fascia by catching first the fascia and then the skin closest to the surgeon with the needle and then taking skin and finally fascia on the other side.

Urinary tract infection, unexplained fever, and pneumonia likewise have rarely occurred. I doubt that early discharge is responsible as all patients are followed with frequent phone calls during the postoperative period. Early cessation of both the Foley catheter and the IV within two hours of the end of the operation followed by early ambulation may reduce postoperative atelectasis and UTI's.

HEMORRHAGE

Intraoperative hemorrhage occurs when a previously nonanemic patient loses greater than 1000 ml of blood or requires a blood transfusion. By doing careful laparoscopic dissection, most profuse hemorrhage situations are avoided or controlled as they occur.

Postoperative hemorrhage is any bleeding event that requires therapy, either conservative or operative. In my experience postoperative bleeding has occurred in only one case secondary to a hemorrhagic ovary stuck to the vaginal cuff. I treated it with Gelfoam and silver nitrate and family donor transfusion unsuccessfully before mobilizing it from the cuff with another laparoscopic procedure.

Postoperative hematomas were frequent with the early use of the MULTIFIRE ENDO GIA 30 (U.S. Surgical, Norwalk, CT) for the upper uterine pedicle during hysterectomy and oophorectomy. I have no experience with postoperative hematoma.

Transfusion rates are often misleading as they usually include autologous blood, that may be given back to the patient on a routine basis. Presently I rarely obtain autologous blood because of the reluctance of most anesthesiologists to transfuse it. Nonautologous blood transfusion has been necessary in six of my cases (3%) for replacement of intraoperative blood loss.

CUFF DEHISCENCE

Cuff dehiscence is very rare following vaginal cuff closure using laparoscopic techniques to bring the endopelvic fascia together vertically in the midline. I am aware of some cuff breakdowns that my colleagues who use a transverse cuff closure have endured. I had one episode back in March 1991 of a peritoneovaginal fistula that was noted on routine cuff check six weeks postoperatively. The patient had been sexually active the day before and had experienced some pain. A laparoscopic closure was accomplished and again it broke down, again after coitus. Finally a vaginal repair using chromic catgut was successful.

URINARY TRACT COMPLICATIONS: prevention and detection

Ureteral and bladder injuries may be expected with complicated cases but are less suspected in routine operations and failure to recognize them during these cases or suspect them early postoperatively results in much patient dissatisfaction. These injuries most commonly are associated with the laparoscopic ligation of the uterine artery, but surgeons must be aware that both bladder and ureteral injury may occur during the “easy” vaginal part of a LAVH.

While ureteral protection is advocated by all, how to best achieve it is hotly disputed. This author remains committed to prevention of ureteral injury intraoperatively by ureteral identification often with dissection and by cystoscopy at the conclusion of the procedure. Isolation by ureteral dissection has been criticized as unnecessarily adding time to the procedure. I find the time well spent if ureteral risk is diminished. My patients have not suffered any adverse sequela from this protective measure. Specifically there has been no ureteral devascularization. My early technique of placing a single “sentinel” stitch around the uterine artery as it crosses just above the ureter to serve as a constant reminder of ureteral location is useful with the small uterus but is rarely used today.

Ureteral stents are not used routinely, though both lighted and infrared catheters are available. Most patient’s who have stent placement experience postoperative hematuria; anuria from ureteral spasm following surgery with a stent in place has been reported. Ureteral catheters are necessary when ureteral injury occurs during surgical dissection or the release of a ureteral stricture; in these cases the stent is left in place for at least six weeks. Ureteral stricture can be treated by dividing the stricture longitudinally and leaving the resultant ureterotomy open over a double J stent connecting the kidney to the bladder.

Cystoscopy is done in all hysterectomy cases after the vaginal cuff is closed to check for ureteral patency and bladder injury. Failure to see dye through a ureter can result from ureteral ligation (placement of a suture into or around the ureter), kinking from pulling endopelvic ureteral fascia towards the midline during the high McCall culdeplasty, or ureteral spasm if a ureteral stent was used. Cystoscopy also confirms bladder wall continuity and detects intravesicular suture placement and thermal injury which will be seen as a patchy white area. I use suture instead of staples or bipolar desiccation for uterine artery ligation so that I can remove the suture if ureteral obstruction or a bladder suture is noted on cystoscopy. This has been necessary on more than one occasion.²³

Preoperative IVP for patient with pelvic mass or suspected severe endometriosis is rarely recommended to avoid injury to the ureter.

This author has incurred ureteral injury during uterine vessel ligation with bipolar desiccation and has been close with the ENDO GIA. In 1988, a right ureterovaginal fistula occurred which was treated successfully with a stent. In that case, the injury was secondary either to bipolar desiccation of the right uterine vessels or to the performance of the vaginal portion of the procedure with the hip joint extended in Allan stirrups instead of converting to candy cane stirrups to flex the hip joint. On multiple occasions while using the ENDO GIA inspection of the ureter after putting the ENDO GIA into position but before firing it revealed entrapment of the ureter. It is important to realize that the ENDO GIA is a straight device without staples in its distal 1 cm end and much wider than a Kelly clamp. In addition, during laparoscopic application, the uterine fundus is not usually put on upward traction as occurs in the open abdomen. The ureter at the level of the uterine artery is 15 mm lateral to the cervix. Stapling devices are 12 mm in width leaving little room for error.

Careful techniques of bladder dissection are important. In difficult cases, the bladder may invaginate into a Cesarean section scar and be surrounded by uterine myometrium. When

bladder location is obscured, the surgeon should fill it intermittently during the procedure to check its position and keep the dissection at its junction with uterine muscle.

Urinary retention is a common undetected complication. Most people who undergo general anesthesia experience some degree of temporary inability to voluntarily contract their bladder musculature. It can take weeks for the bladder to regain normal tone if retention occurs. Postoperative urinary retention is more likely to occur with the use of large amounts of fluid for irrigation and hydroflotation. Urine can accumulate rapidly in the bladder in the drowsy patient who is recovering from anesthesia. The Foley catheter should not be removed at the end of operative procedures lasting longer than 2 hours until the patient is awake in the recovery unit and is aware that the catheter is in place, usually 1 hour postoperatively. In centers where IV fluids are not discontinued in the recovery room within one hour of the operation, the Foley catheter should be kept in longer.

A useful protocol if spontaneous voiding does not occur within 3-4 hours after the catheter is removed is to do straight catheterization and administer 25 mg of bethanechol chloride (Urecholine) every 4 hours until spontaneous voiding occurs. This regimen has successfully reduced urinary retention during the past 6 years on our service.

Some endoscopically related injuries to the urinary tract may not become apparent for a few days following surgery. Although the incidence of these complications is low, the surgeon should nevertheless be aware of the risks and look for signs of such injuries that might have occurred. Unexplained fever, abdominal pain, back pain, or abdominal distention may be signs of some injury and should be investigated.

Any possible injury should be investigated as soon as suspected, identified immediately, and repaired. Potential postoperative problems which requiring prompt resolution include fever, CVA tenderness, low urine output relative to fluid intake, hematuria, abnormal vaginal discharge, hydronephrosis, and ureteral colic.

Postoperative recognition of insult to ureteral integrity is done early by obtaining a single shot IVP on anyone reporting lateralized pain of any kind- abdominal, flank, or back. Uncontrollable loss of urine one to two weeks postoperatively requires an aggressive work-up to determine if a ureterovaginal or vesicovaginal fistula is present. Treatment is with a Latzko operation for vesicovaginal fistula and long term catheter placement or surgical reimplantation for ureterovaginal fistula.

The bottom line is that an aggressive approach to ureteral protection can reduce but not eliminate ureteral injury. However, prompt recognition and management can prevent multiple surgical procedures and significant patient morbidity including organ loss.

Ureteral Injury Management

The ureters are commonly injured at the level of the infundibulopelvic ligament, uterosacral ligament or pelvic sidewall due to adhesions resulting from endometriosis, pelvic inflammatory disease, or previous abdominal surgery. During laparoscopic hysterectomy ureteral injury may occur while cutting dense adhesions and fibrotic scar tissue, trying to stop bleeding close to the ureter with bipolar cautery, or in the process of ligating the uterine vessels with bipolar electrosurgery, staples, or suture. **Most ureteral injuries are not identified or even suspected without cystoscopy.** Without cystoscopic availability, one can expect problems. This is particularly true during TLH, even if the surgeon is visually able to identify the ureters. Normal peristalsis may occur in the damaged ureter.

In my experience, all but the grossest of ureteral injuries are discovered during the cystoscopic examination near the end of the operation. These injuries cannot usually be identified laparoscopically. If no dye is seen flowing from the ureter, the surgeon should first try to pass a ureteral catheter. If it passes without resistance the ureter is fine. If it doesn't pass, the surgeon should systematically trace the ureter down into the deep pelvis. Previously ligated vessels must be isolated, skeletonized, and released from all ureteral attachments. Sometimes this entails release of the suture followed by religation. Continued attempts to pass the stent should be made while the laparoscopic dissection ensues. The dissection stops when the stent passes.

Ureteral injury at the level of or just below the infundibulopelvic ligament is usually recognizable early in the operation as urine oozes from it or a distally cut ureter becomes evident on the side of the uterus during dissection of the uterine vessels.

The avoidance of ureter-related complications requires a sophisticated familiarity with pelvic anatomy. When clamps or ligatures are required they should be placed and elevated high enough so that only targeted ligaments and vessels are caught in the clamp. Established operative techniques for skeletonizing the uterine arteries should be followed, so that the ureters will fall away from the operational field as the surgery proceeds. The location of the ureters within the retroperitoneal space should be identified, and a determination made where they and other structures are likely to move during the course of the TLH.

When severe pelvic adhesions are present it is imperative to identify the ureter prior to ligation of the infundibulopelvic ligament. The cardinal ligament should be cut close to the cervix, after checking the panoramic view.

If a ureter is cut or coagulated, it is necessary to make the appropriate repair depending on the extent of injury: reanastomosis or ureteral re-implantation is indicated. When recognized during the surgery, a laparoscopic approach to these procedures can be considered.

Treatment Options for ureteral transection

When recognized, immediate repair of a transected ureter can be done using a combined laparoscopic-cystoscopic insertion of a pig-tail double-J stent and laparoscopic end-to-end anastomosis using four 5-0 polyglactin extramucosal sutures. The proximal stump of the ureter is freed and checked for viability. A 5-0 Vicryl suture is placed in order to hold the two stumps together allowing the urologist to insert a 6 F double J silicon catheter (pig tail), of 26 cm of length through the cystoscope into the ureter crossing the site of the anastomosis. The anastomosis is then completed with four 5-0 polyglactin extramucosal sutures applied at the 12-, 3-, 6- and 9-o'clock positions. The knots are tied extracorporeally using a Clarke-Reich knotpusher. An adequate distance between sutures is mandatory to avoid ischemic damages. At the end of the operation, the anastomosis is checked for leakage by injecting I.V. indigo-carmin dye and observing the anastomosis underwater, laparoscopically. The correct position of the stent is checked cystoscopically and radiologically.

Most surgeons use 4-0 absorbable suture (chromic, Vicryl, or Monocryl) on a small tapered atraumatic needle. Nonabsorbable suture is not used due to its propensity for stone and crust formation. A simple stitch is used, although occasionally a stay suture is required. Ideally a "no touch" technique is employed: the suture is placed to approximate mucosa to mucosa, without holding the ureter. If the ureter is transected, a half spatulated anastomosis is performed from the tip of one end to the apex of the other. Any kind of soft stent (Bard, Cook, Meditech, or Microvasive) can be placed cystoscopically and removed 6 weeks later. Patency is confirmed by either ureterogram or IVP. Ureteroneocystostomy is done if anastomosis is not possible.

Bladder Injury

Bladder laceration may result from a primary umbilical subcutaneous trocar puncture if the bladder is full. This condition is not easily diagnosed intraoperatively, as the surgeon perceives that he is in the preperitoneal space and tries again and when in the true peritoneal cavity cannot see any injury. Leakage from the umbilicus, usually in the recovery room, may be the presentation. Treatment consists of placing an indwelling catheter for 7 to 10 days and prophylactic antibiotics.

The second-puncture trocar can perforate the bladder, especially in a patient who is obese and has had previous pelvic surgery if the trocar is placed too low, especially if the bladder has not been drained of urine. A reliable diagnostic sign is the sudden appearance of gas in the Foley catheter drainage bag. Injection of indigo carmine through a Foley catheter may identify the site of the injury.²⁶ When no bladder distention occurs during surgery without bladder drainage, consideration should be given to inserting a Foley catheter to observe for gas. If an injury is identified intraoperatively and is greater than 7 mm, the defect should be closed, in the majority of cases laparoscopically. Postoperatively the insertion of an in-dwelling catheter for 7-10 days and the prescribing of prophylactic antibiotic are recommended.

The most important factor in treatment is early detection. If the defect is large from manipulation through the trocar sleeve during laparoscopic surgery, it should be closed with a figure-of-eight suture through the surrounding bladder muscularis and a second suture to close the overlying peritoneum. A watertight seal should be documented by filling the bladder with blue dye solution. Postoperative complications may include bladder atony and leaking of urine in the peritoneal cavity which may also lead to peritonitis

Bladder injury can occur during dissection of the bladder off the uterus and cervix or from an inflamed adnexa. In these cases the bladder is repaired using 3-0 Vicryl usually in two layers.

Intravesicular thermal injury can be suspected by cystoscopic visualization of a white patch above the bladder trigone. The area should be reinforced with a laparoscopically placed suture into the bladder musculature surrounding the potential defect.

BOWEL INJURY

Bowel injury during laparoscopic hysterectomy is uncommon and is associated with extensive intraperitoneal adhesions. Two small bowel injuries during enterolysis occurred in 516 hysterectomies.²⁴

Small bowel injuries can be sutured repaired. Small bowel enterotomy may require mobilization from above, delivery through the umbilicus by extending the incision 1 cm, and resection as the injury frequently involves the small bowel mesentery. Alternately, if the hole is confined to the antimesenteric portion, the bowel can be closed with interrupted 3-0 silk or Vicryl tied either externally or with intracorporeal instrument ties. Sterile milk or dilute indigo carmine is instilled into the bowel lumen prior to the closing of the last suture to assure the absence of leakage from the defect and to detect occult perforations near the small bowel mesentery. All enterotomies are suture repaired transversely to reduce the risk of stricture. If the hole involves greater than 50% of the bowel circumference, resection is done. An extracorporeal segmental enterectomy with side to side stapled anastomosis is preferred. The umbilical incision is enlarged to approximately 2.5 cm to permit extrusion and repair of the involved bowel. Using a GIA 60 fired twice, a segmental enterectomy encompassing the lesions is done. The involved mesentery is serially clamped, divided, and ligated with Vicryl 3-0. A functional side-to-side ileoileal anastomosis is constructed with the GIA-60 and a TA 35 used to close the antimesenteric opening. Patency is insured by palpation to assess proper luminal diameter equal to or greater than 2.5 cm; absence

of leakage is confirmed by milking succus entericus through the anastomotic site. The bowel is then returned to the abdominal cavity. Pneumoperitoneum is re-established, and laparoscopic inspection of the anastomosis should reveal no leakage.

Nodules in the muscularis of the anterior or lateral rectal wall can usually be excised laparoscopically.²⁷ Full-thickness penetrative injury to the rectum may occur during this surgery or accidentally during dissection or uterine morcellation. Following identification of the rent in the rectum, often surrounded by fibrotic endometriosis, a #29 or #33 French closed circular stapler [Proximate ILS Curved Intraluminal Stapler (Ethicon, Stealth)] is inserted into the lumen just past the hole, opened 1-2 cm, and held high to avoid the posterior rectal wall. The proximal anvil is positioned just beyond the hole which is invaginated into the opening and the device closed. Circumferential inspection is made to insure the absence of encroachment of nearby organs and posterior rectum in the staple line and the lack of tension in the anastomosis. The instrument is fired, then removed through the anus. The surgeon inspects the donut of tissue representing the excised hole contained in the circular stapler. Once verified, anastomotic inspection is done laparoscopically underwater after filling the rectum with indigo carmine solution.

Alternately, a double-layer transverse repair is performed using 3-0 silk or Vicryl. Stay sutures are placed at the transverse angles of the defect and brought out through the lower quadrant incisions; the trocar sleeves are then replaced into the peritoneal cavity over the stay sutures. The suture is tied either inside the peritoneal cavity with two laparoscopic needle holders or outside as previously described. Suturing is facilitated by use of short self-retaining trocar sleeves without traps (Wolf or Apple).

PERITONITIS AFTER UNRECOGNIZED OR DELAYED PERFORATION.

Delayed bowel injury can result from traumatic perforation that is not recognized during the procedure (Veress needle or trocar puncture or laceration during adhesiolysis or excision) or from thermal damage from any source. Rarely, delayed injuries can occur from perforation of mechanically devascularized bowel or from hemorrhagic ischemic necrosis after mesenteric venous thrombosis. Although the incidence of these complications is low, the surgeon should nevertheless be aware of the risks and look for signs of such injuries that might have occurred. Unexplained fever, abdominal pain, back pain, abdominal distention, altered bowel function, and elevated white blood cell count may all be signs of some injury and should be investigated.

Bowel perforation after thermal injury usually presents 4 to 10 days following the procedure. With traumatic perforation, symptoms usually occur within 24 to 48 hours. At surgery for delayed bowel perforation, gross appearance of traumatic and electrical injuries is the same; the perforation is usually surrounded by a white area of necrosis.²⁸ Microscopic examination of the lesions reveals the persistence of dead amorphous tissue without polymorphonuclear infiltrate following electrical burns. With puncture injuries, there is rapid and abundant capillary ingrowth, white cell infiltration, and fibrin deposition at the injury site.²⁸ The management of delayed bowel perforation with peritonitis consists of a bowel resection of all necrotic tissue with end-to-end anastomosis, copious lavage, antibiotics, and minidose heparin therapy (preferably supervised by a general surgeon).

COMPLICATIONS UNIQUE TO LAPAROSCOPY

(1) Subcutaneous Emphysema

Subcutaneous emphysema occurs when carbon dioxide is insufflated into the subcutaneous spaces. It may result from placement of the Veress needle into the extraperitoneal space of the abdominal wall and/or the omentum; a condition that is usually not discovered until the surgeon places the laparoscope for visualization. When this occurs, the gas should be disconnected allowing the extraperitoneal gas to escape. Fortunately, carbon dioxide is absorbed rapidly and the subcutaneous emphysema begins to resolve by the time the patient transferred in the recovery room. Subcutaneous emphysema may secondarily occur during prolonged laparoscopic procedures as gas gains access through enlargement of the trocar incision in the parietal peritoneum and extra peritoneal surgery. It is important for the surgeon to warn the patient's companions when facial swelling is significant. Subcutaneous emphysema usually dissolves in 12 to 24 hours.

(2) Injury to Abdominal Wall Vessels

The incidence of trocar induced vascular injuries to the abdominal wall during operative laparoscopic surgery is 2%. Though potentially avoidable, either the superficial or deep vessels of the anterior abdominal wall can cause bleeding and hematoma during or after laparoscopy.

The inferior epigastric vessels lie relatively deep in the rectus muscle in the lateral rectus sheath and despite transillumination, these vessels often cannot be seen. Rupture of epigastric vessels may result from increasing use of multiple ancillary sites. These injuries can be minimized by placement of the trocar with laparoscopic visualization and transillumination lateral to the rectus muscles. Management depends on whether the injury is arterial or venous, the amount of bleeding, as well as the location of the injury. Use of bipolar desiccation through the operating channel of an operating laparoscope in front of the trocar and half way between it and the medial portion of the inguinal ring is appropriate. Laparoscopic placement of a through-and-through loop of suture around the bleeding site is sometimes indicated. For moderate bleeding of epigastric vessels, pressures from the balloon of a Foley catheter may tamponade and stop the bleeding.

(3) Injury to large vessels

Catastrophic severe vascular accidents during laparoscopic surgery, involving large vessels (aorta, vena cava and iliac vessels) are fortunately rare. When they do occur, the surgeon and, as soon as possible, a vascular surgeon must usually perform immediate laparotomy and repair the vascular defects.

Shielded trocars should be avoided as they give the surgeon a false sense of security and may cause additional "blunt trauma" from the shield itself as it blasts through the fascia.

On rare occasion a penetration injury to blood vessels at the time of insufflation may be unrecognized. This may lead to gas embolism and death. The classic mill wheel murmur over the pericardium may be heard by the anesthesiologist.

(4) Trocar site incisional hernias

The incidence of incisional hernias after operative laparoscopy is greatly increased if 10 mm or larger trocars are placed at extraumbilical sites. These sites should be closed. If the incision is lateral to the rectus muscle, the deep fascia is elevated with skin hooks and suture repaired. If the incision is through the rectus muscle, the peritoneal defect is closed with a laparoscopically placed suture.²⁹

Incisional hernias present usually within 10 days of surgery. Postoperative discomfort with incisional swelling or distension should be cause for examination. If hernia is suspected, laparoscopic reduction should be considered. I have had one such hernia in September 1991 during a short trial of 12 mm trocar sleeves for Endo-GIA application.

(5) Instrument Failure

Occasionally instruments are faulty. Some, such as a grasper, dissectors, or scissors can be immediately replaced. However, those that are electrically driven are often another matter and vary tremendously in reliability.

If the patient is not grounded appropriately and a monopolar electrosurgical instrument is used, burns to the patient at the return electrode contact sites from incomplete grounding may occur.

When multiple electronic instruments are activated by foot pedals, only one foot pedal should be used at any one time, to avoid activating the wrong instrument.

If an instrument breaks within the abdomen, all pieces should be extracted under direct visualization. If any instrument locks in an open position and won't retract into the trocar sheath, the trocar sheath along with the instrument should be withdrawn from the abdomen; it is rarely necessary to extend the incision.

CONCLUSIONS

In an editorial in the August 15, 1996 issue of The New England Journal of Medicine, it was suggested that, except for abortion, laparoscopic hysterectomy has generated more controversy and discussion than any other type of gynecologic surgery in recent times. The authors of this editorial would surely benefit from learning a little more about the procedure and its evolution before belittling it for the wrong reasons.³⁰

It is difficult to extrapolate indications for the role of laparoscopy in hysterectomy from present publications as the surgeons most skilled in the laparoscopic approach are referred the difficult cases and rarely see those that could be easily performed vaginally. The future place of laparoscopic hysterectomy will be determined by the increased familiarity and skill of surgeons with vaginal procedures, stimulated by doing the difficult part of a "laparoscopic assisted vaginal hysterectomy" vaginally. I suspect that over 50% of indicated hysterectomies can be performed using the vaginal route only without laparoscopy. The laparoscope may convert more than one-half of the remaining cases to a vaginal procedure. I estimate that vaginal hysterectomy, after an initial diagnostic laparoscopy, will be possible in one half of those with some relative contraindication to the vaginal approach. One half of the remaining indicated hysterectomies will require laparoscopic oophorectomy or adhesiolysis of the upper portion to be removed, i.e., a LAVH. Of the remaining hysterectomies, 12.5% of the total, the skilled laparoscopic surgeon will do a total laparoscopic hysterectomy and consider conversion to abdominal hysterectomy in less than 1%.

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