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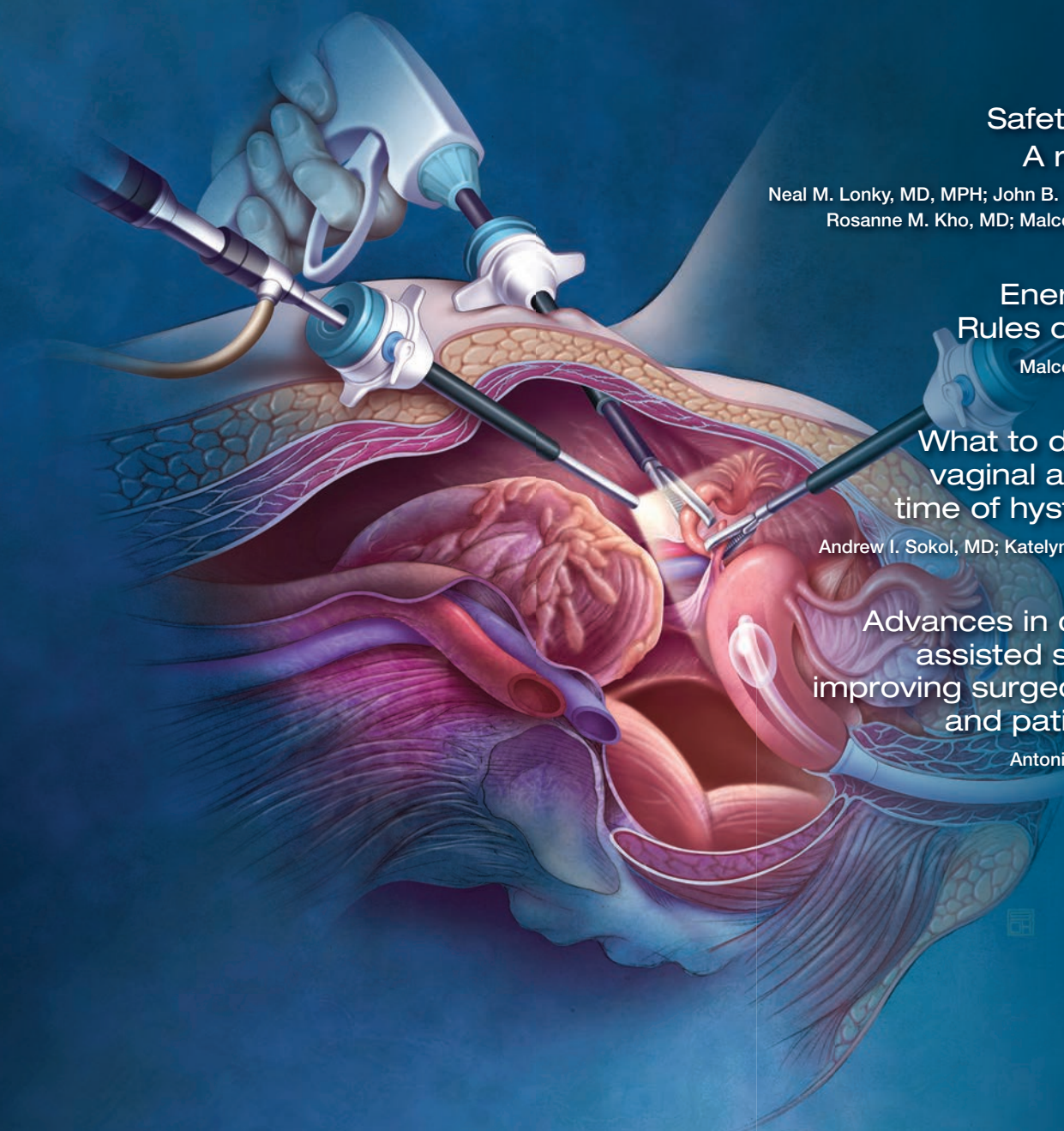
OCTOBER 2015

INNOVATIONS IN PATIENT SAFETY FOR WOMEN'S HEALTH

Minimally invasive gynecologic surgery



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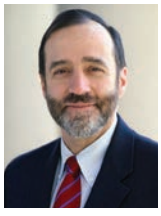
Every surgeon knows that, if you operate, complications will follow. Surgeons are perfectionists and strive to reduce complications through years of diligent personal training and continuous quality improvement. Surgeons hate complications, especially those that might be preventable (such as retained foreign bodies, wrong site surgery, and medication errors). In this special issue of OBG MANAGEMENT, world-renowned experts focus on topical issues in safety in minimally invasive gynecologic surgery (MIGS). In the roundtable, Drs. Neal Lonky, John Gebhart, Rosanne Kho, and Malcolm Munro discuss important issues in MIGS, including the need to prioritize the vaginal and laparoscopic routes of hysterectomy and the role of single-port surgery. In a concise yet detailed discussion of safety issues related to radiofrequency and ultrasound energy devices, Dr. Munro alerts us to the dangers of heat injury and direct and capacitative coupling. Drs. Andrew Sokol and Katelyn Smithling provide guidance on preventing apical prolapse of the vagina following hysterectomy. Dr. Antonio Gargiulo explores the rapidly expanding role of simulation training with computer-assisted (robotic) surgical simulators and predicts that, instead of learning surgery on patients, future trainees will gain skills in a simulation environment. We thank the master surgeons who participated in this special issue for providing guidance and helping us to reduce complications. Our patients are the beneficiaries of the wisdom provided herein.



—Robert L. Barbieri, MD
Editor in Chief, OBG MANAGEMENT

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FRONTLINE MEDICAL COMMUNICATIONS
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Safety in gynecologic surgery: A roundtable discussion

A minimally invasive approach offers many advantages over laparotomy-based surgeries, but a focus on safety remains paramount. Here, 3 leading surgeons share their views on the optimal approach to gynecologic procedures to ensure safety as well as efficacy.

Expert panel featuring Neal M. Lonky, MD, MPH, moderator; with John B. Gebhart, MD, MS; Rosanne M. Kho, MD; and Malcolm G. Munro, MD

In this comprehensive discussion, experts set the stage for an extended look at safety issues in minimally invasive gynecologic surgery

The minimally invasive approach to gynecologic procedures has gained tremendous ground in the past few years. The technology available to the ObGyns who perform these surgeries also has evolved rapidly. Because safety is a top priority, variables that contribute to successful surgery, such as selection of the most appropriate approach, use of energy devices, and the application of techniques designed to minimize the risk of complications are paramount.

In this roundtable discussion, moderated by OBG Management Contributing Editor Neal M. Lonky, MD, MPH, 3 leading surgeons debate ways to optimize safety in minimally invasive gynecologic surgery, including selection of the approach in a spectrum of clinical situations, use of advanced energy systems in laparoscopy, the role of adhesion barriers, and the tools and techniques used for closure of the vaginal cuff.

What is the optimal approach to hysterectomy?

Neal M. Lonky, MD, MPH: In our discussion of minimally invasive gynecologic surgery, let's begin with hysterectomy. How do you choose the optimal approach to ensure patient safety and surgical efficacy?

Malcolm G. Munro, MD: In general terms, when a patient opts to undergo total hysterectomy, the vaginal approach is preferred. If a vaginal approach is not possible, laparoscopic hysterectomy is the next best choice. Laparotomic hysterectomy—that is, hysterectomy via laparotomy—should be performed only when experts in vaginal and laparoscopic hysterectomy deem, for technical reasons, that minimally invasive approaches are not appropriate.

Dr. Lonky: Is there evidence to back this view?

Dr. Munro: These principles are derived from evidence from randomized trials summarized in a Cochrane review[1] and supported by organizations such as the AAGL[2] and the American College of Obstetricians and Gynecologists.[3] The main drivers for these recommendations are a plethora of well-designed studies that demonstrate that both adverse events and direct costs are reduced with the vaginal approach—not to mention the absence of abdominal incisions.

Although initially there was uncertainty regarding the risks associated with laparoscopic hysterectomy, it appears that, with the experience and evolution of technique facilitated by time, those risks fall to a degree that makes the procedure safer than hysterectomy performed via laparotomy.[4]

John B. Gebhart, MD, MS: The optimal surgical approach should depend on the underlying condition (abnormal uterine bleeding [AUB], fibroids, adnexal mass, endometriosis,

etc), symptoms, pertinent medical/surgical history, physical examination, and the surgeon's skill set. I agree with Dr. Munro that, in the absence of any obvious indication to "approach from above," a vaginal approach should always be considered as the primary route. The literature is awash in data showing that vaginal hysterectomy is the safest, least morbid, and most cost-effective approach to hysterectomy.

Rosanne M. Kho, MD: It is clear that the vaginal approach is preferred for benign hysterectomy. In my opinion, there are only 2 exclusion criteria for the vaginal approach:

- **Pain.** Patients who experience noncyclic pain and have never been previously evaluated with laparoscopy for evaluation of pain or who are known to have deep infiltrating endometriosis should undergo either laparoscopic or robotic hysterectomy, depending on the surgeon's skill set.
- **Biopsy-proven cancer or a high index of suspicion for cancer.** Patients who present with abnormal bleeding or worrisome imaging findings should have an endometrial biopsy. Those with pathology-confirmed high-grade endometrial cancer and complex endometrial hyperplasia with atypia should not undergo vaginal hysterectomy if morcellation will be required. In addition, any case with imaging showing worrisome features for large adnexal and uterine masses should not be approached vaginally with manual morcellation because of the concern for dissemination of disease.

With adequate surgical training and in the absence of the 2 criteria above, every patient requiring a hysterectomy for benign indications benefits most from the vaginal approach, compared with the other routes. Nulliparity, previous cesarean delivery or pelvic surgery, a uterus larger than 12 weeks' size, and a high body mass index (BMI) should not be considered contraindications to the vaginal approach. In addition, with appropriate technique and training, removal of the adnexae (as in patients with a BRCA mutation) or risk-reducing salpingectomy also can be performed safely with the vaginal route.

OBG MANAGEMENT expert panel

Neal M. Lonky, MD, MPH, moderator of this roundtable discussion, is Clinical Professor of Obstetrics and Gynecology at the University of California, Irvine, and a member of the Board of Directors of the Southern California Permanente Medical Group. He also serves as an OBG MANAGEMENT Contributing Editor.

John B. Gebhart, MD, MS, is Professor of Obstetrics and Gynecology at Mayo Clinic in Rochester, Minnesota.

Rosanne M. Kho, MD, is Associate Professor of Obstetrics and Gynecology at Columbia University Medical Center in New York City, where she also serves as Section Director, Urogynecology, and Co-Director of the MIGS Fellowship Program.

Malcolm G. Munro, MD, is Professor of Obstetrics and Gynecology at the David Geffen School of Medicine at UCLA and Director of Gynecologic Services at Kaiser Permanente, Los Angeles Medical Center in Los Angeles, California.

Dr. Gebhart reports that he is a consultant to Allergan and AMS and receives royalties from Elsevier for work published in UpToDate. Dr. Kho reports that she is a consultant to Marina Medical and Symmetry Surgical. Drs. Lonky and Munro report no financial relationships relevant to this article.

Advantages of vaginal hysterectomy

Dr. Lonky: What are some of the other advantages of the vaginal approach?

Dr. Gebhart: Vaginal hysterectomy is the least invasive approach, with many considering it the original "natural orifice surgery." A single, small incision is all that is required. It is clearly the most cosmetically appealing scar, compared with multiple port–site scars from the laparoscopic or robotic approach or the scar from a "mini" or "maxi" laparotomy.

Given the single incision, the risk of wound infection or injury to underlying structures is reduced. It is an ideal surgery for any BMI and is performed usually in less than 1 hour. Last, because the entire uterus is removed (no supracervical approach or need for power morcellation), vaginal hysterectomy avoids the need for

reoperation to address later Pap smear abnormalities, bleeding, etc.

If there is a risk, it is related to dissection of the vesicovaginal space and dissection near the bladder. That risk exists with any hysterectomy approach, however.

How to select a surgical approach

Dr. Lonky: What parameters do you use to select the surgical route to hysterectomy?

Dr. Munro: For patients with benign disorders, a number of features should be taken into account when considering vaginal hysterectomy. They include uterine size, previous abdominal and pelvic surgery, and vaginal access. In reasonably skilled hands, size itself is less of an issue than access to the cervix and upper vagina.

Women known to have pelvic adhesive disease secondary to endometriosis, pelvic infection, or earlier extensive abdominal surgery may best be approached laparoscopically. BMI is not generally a consideration. In fact, a high BMI is an incentive to perform vaginal hysterectomy, and there is ample evidence that laparoscopic hysterectomy also can be performed safely.

A high body mass index is an incentive to perform vaginal hysterectomy

Dr. Kho: I would have to say that patient selection is key, necessitating a thorough patient evaluation and workup. Adequate surgical training also is vital. Gynecologic surgeons must take it upon themselves to acquire additional training to advance and refine their skills and understand the issues surrounding surgery.

Dr. Lonky: How does the approach to hysterectomy affect recovery? And what interventions make the surgery less traumatic, leading to a speedier recovery?

Dr. Kho: We all know that intraoperative blood loss and operative time correlate well with postoperative complications. By preventing massive blood loss and ensuring appropriate flow of surgery, we can increase the likelihood of a smooth recovery.

Dr. Gebhart: The fact that, in vaginal hysterectomy, there is one small incision to work through keeps pain to a minimum. Various retractors or a self-retaining retractor are utilized for exposure, again minimizing postoperative pain and enhancing recovery.

Dr. Munro: Vaginal hysterectomy can be performed in a short-stay environment, with discharge home in 8 to 24 hours. The absence of any abdominal incisions facilitates return to some normal activities quickly—although those who work in environments where lifting is required must wait an adequate amount of time to allow for vault healing.

For all patients, sexual intercourse must be deferred for at least 6 weeks or even longer to reduce the risk of wound disruption.

Laparoscopic hysterectomy provides virtually the same benefits as vaginal hysterectomy, leaving laparotomic hysterectomy as the approach that requires an abdominal incision, a relatively prolonged hospital stay, and a prolonged period of recovery during which activities generally are minimized.

How do we ensure both safety and cost-effectiveness?

Dr. Lonky: How can we get the most bang for our buck in different surgical scenarios and remain safe?

Dr. Munro: We can avoid hysterectomy when possible and, when it is deemed necessary, we can choose the safest approach. It is apparent, from large-scale studies, that use of the so-called robotic surgical system adds to the cost of laparoscopic hysterectomy without any apparent benefit—and possibly with a slight increase in complications.[5–7]

Dr. Gebhart: We need to ask ourselves, "What condition am I operating on and what approach is safest in my hands and most cost-effective?" For example, if a patient has the symptom of heavy menstrual bleeding and a large adnexal mass, at least a portion of the case will need to be done abdominally (laparoscopic or laparotomic). It is possible that the adnexal mass could be removed laparoscopically and the hysterectomy performed vaginally—sure. Conversely, it might be easiest to perform the whole procedure laparoscopically. The surgeon needs to consider all findings when deciding on an approach.

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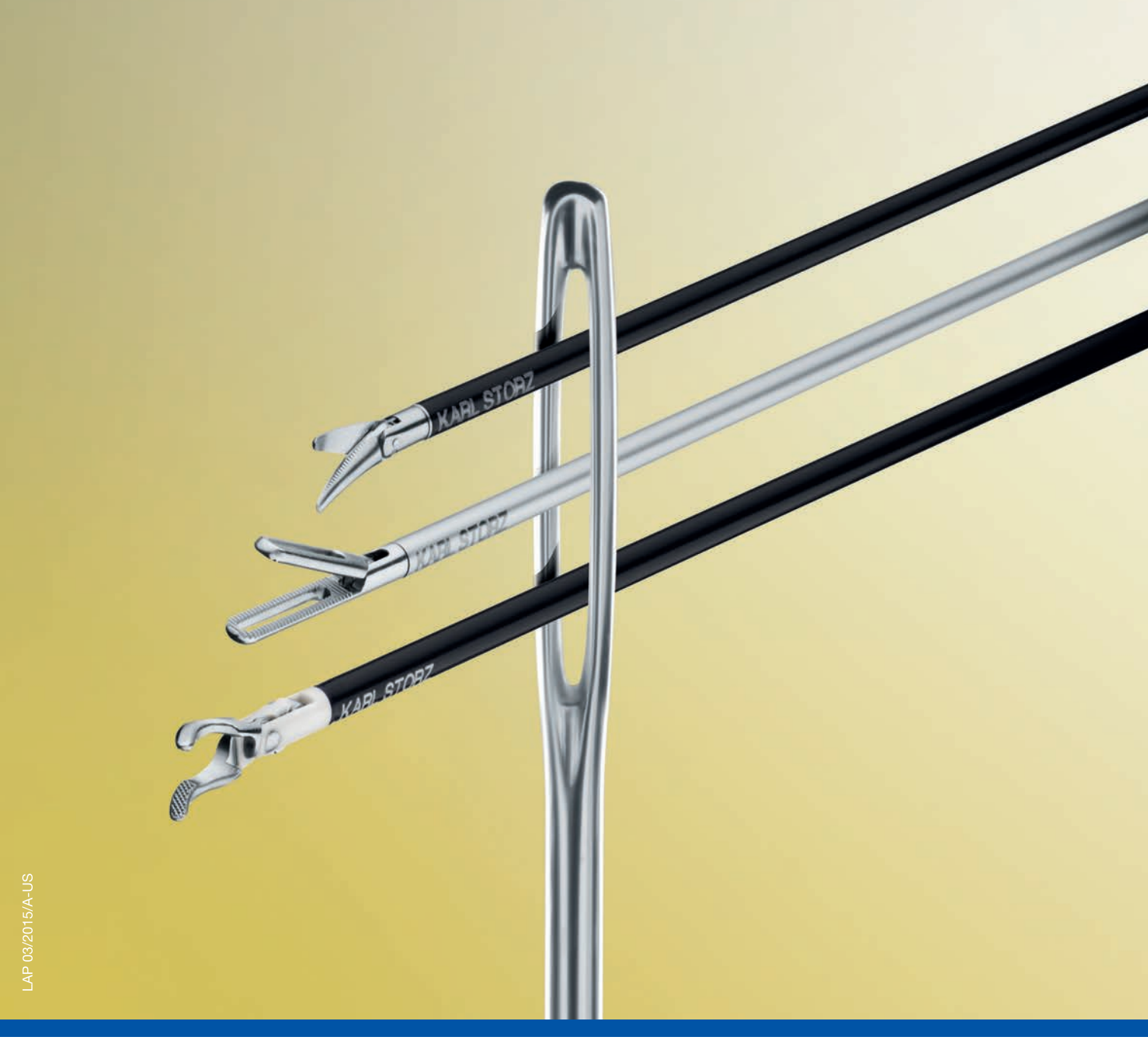

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What is the role of robot-assisted hysterectomy?

Dr. Lonky: Is there any evidence that hysterectomy would be safer, with a better recovery, if a robot-assisted approach were chosen rather than conventional laparoscopic or open surgery?

Dr. Munro: None. First of all, I may seem to be something of a contrarian, but I take exception to our adoption of this term "robot." At present, there is nothing robotic about such surgery, as the device is simply an assemblage of 3-dimensional video imaging, a laparoscope holder, and a number of hand instruments that, together with the laparoscope, can be manually manipulated by a surgeon sitting in a remote location. Nothing is automated, the basic requirement for anything we consider robotic. So what we are dealing with is a microprocessor-based remote-controlled system for the performance of laparoscopic surgery.

A number of comparative studies have demonstrated that microprocessor-assisted laparoscopic hysterectomy requires longer operative time and is more expensive than standard laparoscopic hysterectomy.[8–13] Large-scale epidemiologic studies are in accord,[14] and reviews of the literature have drawn the same conclusion.[15–17]

Robot-assisted technology has allowed conversion of open abdominal cases to an endoscopic approach, especially in gynecologic oncology

Patient acceptance is another issue. When women are presented with pictures of the incision patterns of the various approaches to gynecologic surgery, the vast majority choose an alternate approach rather than deal with the plethora, location, and dimensions of incisions associated with microprocessor–assisted laparoscopic surgery.[18,19]

Dr. Gebhart: I'm not aware of any evidence that the robot-assisted approach offers safer or better outcomes for benign hysterectomy. This enabling technology has allowed conversion of open abdominal cases to an endoscopic approach—especially in gynecologic oncology—which is highly beneficial, particularly in morbidly obese patients. Skilled laparoscopists would argue that the robot offers little benefit over traditional laparoscopy and only increases cost of the case.

Dr. Kho: The issue here really should be robotics versus open surgery. Although I'm a staunch proponent of vaginal surgery, I am also a strong advocate of all routes of minimally invasive surgery. Not everyone is skilled in conventional laparoscopy. Robotics is an enabling tool, allowing patients to benefit from the minimally invasive approach (robot assistance) when they would have been opened otherwise.[20,21] Robotics is easier to learn than conventional laparoscopy. We are finally seeing a decline in the abdominal hysterectomy rate with the introduction of robotics.

Current studies may not show that robotics is safer and promotes faster recovery, but we know from studies that it has the same complication rates as conventional laparoscopy. Where robotics loses the debate is always with its increased cost.

When is single-port surgery advantageous?

Dr. Lonky: Have you found single-port surgery to be advantageous in certain scenarios? If so, when do you prefer single-port versus multiport surgery, and what are the advantages of each?

Dr. Kho: A high percentage of hysterectomies are approached vaginally in my practice. When feasible, I do perform single-incision laparoscopy for patients requiring salpingectomy, adnexectomy, and/or ovarian cystectomy. I want my patients to avoid the possible adverse consequences of multiple ports, such as trocar-site bleeding, hernia, and subsequent formation of painful keloids.

Dr. Munro: The work I do is generally not amenable to a single-port approach, so it is difficult for me to answer your question from the perspective of personal experience. However, it would appear that there are procedures that are suitable for single-port access, and there is evidence that they can be performed effectively and safely.

It is my impression that microprocessor-assisted laparoscopy may have a role in the single-port process in a way that could facilitate more complex procedures.

How a "comparative effectiveness" approach to hysterectomy care can improve outcomes

In 2011, the Southern California Permanente Medical Group (SCPMG) began recording data from clinical practice—as documented through the electronic health record—into a prospective registry for hysterectomy care. Some early findings have been reported.[1,2] Similar efforts are under way across the country, most notably the Center of Excellence in Minimally Invasive Gynecology (COEMIG) database organized by AAGL, whose focus is to evaluate and improve outcomes using a minimally invasive approach. The SCPMG registry information also will serve as a resource to share with COEMIG and other data-collection efforts.

These endeavors create the opportunity for us to compare the impact of different sets of variables that can affect the safety, efficacy, cost-effectiveness, and recovery associated with hysterectomy, from variables particular to the surgical case and surgeon to those related to the care setting and patient. With universal use of the registry tool, tens of thousands of cases—reflecting the practice of hundreds of surgeons and assistant surgeons—will support multivariate statistical analyses.

At SCPMG, we are leading the effort by engaging physicians and support staff to record key variables in a proprietary and efficient manner during routine care. These variables can be reduced and analyzed later under a prospectively designed research protocol supervised by our internal review board. As a "learning" and "researching" organization, SCPMG should be able to create a model that can assist in the counseling of women about the relative benefits, risks, and costs of hysterectomy, given the variables present at the time the clinical decision is made.

By requiring surgeons to complete particular data forms, SCPMG reminds them about important variables: preoperative antibiotics, prophylaxis against thrombosis, vaginal cavity inspection after hysterectomy, postoperative cystoscopy, and administration of blood products.

Some findings

The SCPMG database has shown bowel-related complications (obstruction, significant ileus) to be one of the top reasons for extended hospitalization and readmission, and there is a paucity of data on the use of adhesion-prevention interventions in this cohort. This represents a significant opportunity for comparative effectiveness research.

This database was established prior to concerns about power morcellation. After hundreds of laparoscopic supracervical hysterectomies and 5 years of follow-up, no cancers have been reported.

Bleeding and intraoperative blood loss affect recovery from hysterectomy, as well as complication rates. Preoperative interventions for uterine bleeding may reduce these risks, and the use of leuprolide acetate, combination oral contraceptives, or oral or intrauterine device–delivered progestins could benefit from comparative effectiveness evaluations.

Databases such as the SCPMG Hysterectomy Research Registry are a key strength of our medical group, addressing questions such as "What works?" "What is safest?" "What are the most valuable tools and strategies for hysterectomy care?" and "What gets the patient home with the most efficient recovery?" We are fortunate that such registries are becoming more pervasive in our organization across many specialties.

—NEAL M. LONKY, MD, MPH

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Which energy devices are preferred?

Dr. Lonky: What is your preferred energy device in laparoscopy and why?

Dr. Kho: I use any of the advanced bipolar or ultrasonic vessel-sealing devices that are provided to me at my institution.

Dr. Gebhart: I have no preferred energy device.

Dr. Munro: No single system or device is ideal for all situations. Monopolar radiofrequency (RF) instruments are superior at focal or linear vaporization, making them uniquely useful for vaporization of endometriosis or the incising of peritoneum or adhesions. These instruments are especially useful when configured as scissors that can be alternatively used as mechanical cutting devices and, when directly coupled to a grasping forceps, can deliver energy for small-vessel sealing.

While this configuration, or simple monopolar grasping instruments, can be used to effectively seal vessels, bipolar RF devices designed to seal larger vessels can do so even more effectively, with minimal collateral injury from thermal spread.

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I use ultrasound-based coagulating and cutting shears at laparoscopic myomectomy for a number of reasons:

- limited collateral thermal injury
- an absence of the smoke associated with RF incision and dissection
- ability to quickly switch between a blade, cutting shear, and coagulation configuration
- rugged design that facilitates dissection based on firm traction and counter-traction.

Each of these selections is chosen for its particular efficacy, with safety principally based on a clear understanding of the risks of the device or system. Cost can be mitigated in a number of ways. (For more on ensuring safety during use of energy devices, see "Energy safety: Rules of the road," on page S10 of this issue.)

Is there a role for adhesion barriers?

Dr. Lonky: What is the role of adhesion barriers in gynecologic surgery? Are there any perceived advantages in preventing or reducing the risk of certain complications?

Dr. Gebhart: There may be a role for adhesion barriers in gynecologic surgery but likely not for most hysterectomies. These products may have some benefit in younger patients undergoing surgeries that can potentially impact future fertility (myomectomy, resection of endometriosis/endometrioma, etc). However, we lack abundant evidence that they are beneficial in cases such as repeat cesarean. So I think more and better data are needed to guide the use of adhesion barriers.

Bipolar radiofrequency devices can seal larger vessels effectively with minimal collateral injury from thermal spread

Dr. Munro: Although there is evidence that, in selected circumstances, adhesion barriers can reduce the incidence of adhesions identified at second-look laparoscopy,[22] there is an absence of data on the utility of these agents at improving important outcomes such as pelvic pain or infertility. It is important to know, for example, that TC-7 (Interceed) may actually increase the incidence of adhesions should the barrier be placed on a bloody surface.[23]

Dr. Kho: By ensuring hemostasis, no matter the procedure or approach, we help prevent adhesions. I prefer routine copious irrigation and careful inspection of the pedicles toward the end of a procedure. I do not use adhesion barriers routinely in surgery.

What is the optimal way to close the vaginal cuff?

Dr. Lonky: What variables do you see as advantages and risks when closing the vaginal cuff during hysterectomy? Does suture type play a role? Do you close the cuff using laparoscopic equipment or from below via the vagina?

Dr. Munro: Unnecessary controversy surrounds this issue. While it is reasonable to assert that the method should be based upon the preferences of the surgeon, it is clear that, in some instances at least, a laparoscopic approach is necessary because vaginal access is impossible. Moreover, as there is evidence that routine performance of an apical suspension procedure is necessary, closure should be planned with this in mind.[24]

Closure of the cuff requires that adequate tissue be captured in the suture—and it is also important to capture tissue that hasn't been coagulated by the energy source used to transect the vaginal epithelium.

Dr. Kho: I think you are getting at the issue of vaginal cuff dehiscence with this question, Dr. Lonky. We do know that there is an increased incidence of vaginal cuff dehiscence after laparoscopic and robotic procedures.[25] What we do not know yet is whether this is due to the use of energy during colpotomy or the method of suturing. Although one study has suggested that a vaginal approach to suturing lowers the risk of vaginal cuff dehiscence, I am not convinced that vaginal suturing (as in laparoscopic-assisted vaginal hysterectomy) is the answer.[26] We would need a very large sample of patients randomly allocated to only a single variable with long follow-up to know the true answer to this issue.

Dr. Gebhart: Awareness of surrounding structures is paramount. Visualization is critical but misunderstood. For example, in many instances, vaginal closure of the cuff affords less visualization than closure from

above. However, when you've learned how to expose the cuff vaginally, it is very simple to close. In contrast, vaginal cuff dehiscence after robotic hysterectomy is well documented, even though the robot offers "improved visualization."[27]

I'm convinced that what you do with the suture (adequate tissue purchase and approximation, with good visualization) is more important than the type of suture you use. I prefer 1-0 Vicryl to close the vaginal cuff.

As a reconstructive pelvic surgeon, I advocate, with Dr. Munro, for suspension of the vaginal apex at the time of hysterectomy in addition to adequate closure of the vaginal cuff.

Dr. Lonky: Thank you all for your participation in discussion of ways to optimize outcomes in gynecologic surgery! ■

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Energy safety: Rules of the road

Advanced energy devices facilitate many surgical procedures—but it is imperative to know their optimal uses, associated risks, and benefits

Malcolm G. Munro, MD

Dr. Munro expands the discusssion on energy safety with a review of device types, focusing on injury prevention

Energy-based surgical devices can incorporate laser, ultrasound, microwave, or radiofrequency (RF) electrical sources. When properly applied, they can effectively assist the surgeon in the performance of vaginal, laparoscopic, and hysteroscopic procedures, as well as those performed via laparotomy.

RF electricity is by far the most versatile of these energy sources, but ultrasound-based devices also have become valuable additions to the armamentarium of the gynecologic surgeon. In this article, I focus on both of these energy entities.

Safe use of energy-based surgical devices begins with an intimate understanding of the mechanisms by which these systems effect tissue. A detailed resource for energy-based surgical devices is the Fundamental Use of Surgical Energy (FUSE) program, developed by the Society of American Gastrointestinal and Endoscopic Surgeons. The FUSE program is available open access at www.fuseprogram.org.

RF electricity devices

RF electricity, originally developed for surgery in the late 19th Century, causes rapid oscillation (at RF typically in the range of 300–500 KHz) of intracellular ions when focused on tissue with appropriate electrodes. This rapid oscillation results in friction-based elevation of intracellular temperature. When this temperature reaches the range of 60°C to 99°C, immediate intracellular coagulation and desiccation occur; if the intracellular temperature reaches or exceeds 100°C, the fluid in the cell is converted to gas (it boils), and the now-gaseous cytoplasm expands, causing the cell to explode in a process called vaporization.

These processes can be exploited, depending on the density or concentration of the current, to coagulate tissue and hemostatically seal vessels (for example, with suitably designed grasping forceps). If highly focused (with use of needle-, hook-, or blade-shaped electrodes), RF electrical energy can vaporize tissue and, if the vaporization extends in a linear fashion, transect it.

To achieve these effects, all RF electrosurgery is bipolar, as 2 electrodes connect with the patient to deliver the energy created by the electrosurgical unit (ESU). With monopolar instrumentation, one electrode is dispersive, designed to defocus the energy, while the "active" electrode is structured to focus the energy on the tissue.

Bipolar instruments also are connected to the ESU but have both electrodes integrated into their design; in some instances, one of the electrodes is designed to be "dispersive" and not create a tissue effect, while in others, such as grasping forceps, both electrodes are "active" because they focus the current, thereby contributing to the impact on tissue.

"Advanced" bipolar devices improve vessel sealing by measuring tissue temperature

Dr. Munro is Professor of Obstetrics and Gynecology at the David Geffen School of Medicine at UCLA and Director of Gynecologic Services at Kaiser Permanente, Los Angeles Medical Center in Los Angeles, California.

The author reports no financial relationships relevant to this article.

and/or impedance in a way that allows the microprocessor in the proprietary ESU to calculate a measured amount of energy delivery, thereby optimizing the integrity of the vascular seal while minimizing lateral thermal spread and the generation of

Energy-related injuries and how to avoid them

Energy source	Instrument type	Injury mechanism	Risk reduction measures
Radiofrequency (RF) electrical energy	Monopolar and bipolar	Inadvertent activation	Remove and sheathe instruments when not in use
			Isolate foot pedals to reduce the risk of accidental depression
			Surgeon-only activation for the foot pedal
		Active electrode injury	Isolate vessels from nearby ureter, bowel prior to desiccation/coagulation
			Allow the active electrode(s) to cool prior to touching other tissue
	Monopolar only	Dispersive electrode injury	Secure attachment of dispersive electrode to normal underlying skin
			Use ESUs and dispersive electrodes with separation detection mechanisms
		Insulation failure (laparoscopic instrumentation)	Check instruments for insulation breaks before and during surgery
			Keep shafts of devices separated from important structures when activating
			Use low-voltage outputs ("cut") for ALL techniques—cutting and desiccation/coagulation—except fulguration
			For laparoscopic surgery, consider an active electrode monitoring system
		Direct coupling	Ensure that only the target tissue is touched by a grasping instrument for intentional direct coupling
			At laparoscopy, do not use noninsulated instruments with monopolar instrumentation
		Capacitative coupling* (laparoscopic and hysteroscopic	Avoid use of monopolar RF instrumentation with "single port" access or operative laparoscopes
			For laparoscopic surgery, consider using an active electrode monitoring system
			For hysteroscopy, ensure that the external sheath of the RF resectoscope maintains an intimate connection with the cervix—do not overdilate or withdraw the external sheath when resecting or desiccating
			Use low-voltage outputs ("cut") for ALL techniques—cutting and desiccation/coagulation—except fulguration
Ultrasound	Shears or blade	Injury from retained heat	Allow the oscillating blade to cool prior to touching other tissue

Abbreviation: ESU, electrosurgical unit. *See glossary of terms on page S13A.

unnecessary smoke that otherwise can obscure the operative field.

Ultrasound-based devices

The basic concept of ultrasound-based surgical devices is the conversion of ultrasonic vibration at 55 KHz to a synchronous linear mechanical oscillation by a device called a pizoelectrode. The energy created results in some combination of mechanical transection of tissue, tissue desiccation and protein coagulation, and cellular vaporization, the latter in part because of thermal protein denaturation and because of a lower local atmospheric pressure.

These devices originally involved simple blades, but now the most commonly used instruments have a single-jaw design that allows the linear oscillating blade to function as a knife or, by using the single articulated jaw, to compress intervening tissue. This design facilitates either a dominant scissors-like action for cutting or, by reducing the excursion of the blade, increased tissue desiccation, protein coagulation, and resultant vessel sealing.

Ultrasound-based devices create a fine mist but do not develop the obscuring smoke associated with RF-based instrumentation. Moreover, they do not have issues of current diversion that can occur with monopolar RF devices. However, they are not as effective at focal vaporization, and their capacity to seal larger-diameter vessels is reduced, compared with advanced bipolar devices in particular.

To prevent unintentional activation injuries, place all instruments in protective sheaths or pouches when not in use

How to prevent injury

RF electricity

With RF devices, thermal injuries generally occur secondary to one of the following:

- **unintentional activation**
- **direct injury** from one or both electrodes
- **current diversion,** which may be caused by insulation defects, direct coupling to another conductive device, or capacitative coupling, a process that can occur through adjacent instruments that are not in contact or even those that are coated with intact insulation (**TABLE,** page S11).

Current diversion is essentially unique to monopolar RF instrumentation, as the entire portion of the patient interposed between the active and dispersive electrode is at risk. For bipolar instrumentation, only the target tissue is interposed between the 2 electrodes; consequently, the notion of current diversion is practically insignificant.

To prevent **unintentional activation** injuries, place all instruments—especially monopolar devices—in protective sheaths or pouches when not in use; do not leave them in or on the patient. When foot pedals are used for activation, they should be placed so that only the surgeon has access. And only the surgeon should activate the ESU.

Direct injury from **partial detachment** (and resulting increased current density) of the dispersive electrode is largely eliminated with most modern ESUs if used with specialized electrodes designed to shut off the generator if not properly applied to the patients. However, because some devices in circulation may lack this feature, take care to ensure secure attachment over an un-scarred area as an important risk-reducing measure.

To reduce the risk of injury from **extension of the active electrode's tissue effects**—whether it is a monopolar or bipolar instrument—maintain an awareness of the tissues adjacent to the dissection, as extension of the zone of desiccation/coagulation can result in significant injury.

Although safe use of monopolar RF instrumentation is clearly feasible, one must work with continuous diligence to reduce the risk of injury secondary to current diversion, particularly with laparoscopic and even with hysteroscopic surgery. Clearly, preoperative inspection of the shaft of laparoscopic monopolar RF instruments is important, but the most devastating injuries come from tiny defects that cause zones of high current density; such defects may occur intraoperatively as a result of instrument "clashes."

Diligence requires maintenance of a wide view of the operative and surrounding fields to ensure that bowel or other important structures are not touching or near an activated monopolar RF instrument. The risk of

insulation failure and arcing to tissue can be minimized by limiting the ESU output to a low-voltage "cut" waveform, both for cutting and for desiccation/coagulation of blood vessels or vascular pedicles. Not only does use of the low-voltage output reduce this risk but it also improves the quality of the vascular (or even fallopian tube) seal that is created.

Hazards of unintentional direct coupling

Direct coupling can be used to great effect (this is the "buzz me" technique when, for example, a vessel is grasped with a tissue forceps and then coagulated by touching the forceps with an activated electrode), but when it happens unintentionally, the result may be catastrophic. When "intentional" direct coupling is employed, the surgeon and assistants should ensure that the inert but conductive device (usually a forceps of some type) is not in contact with any tissue other than the target. Avoid using any uninsulated probes, needle drivers, or other intraperitoneal hand instruments when monopolar instruments are in the peritoneal cavity, especially during laparoscopic surgery.

How to prevent capacitative coupling

Many find the concept of capacitative coupling difficult to understand—and this makes prevention of related injuries more difficult. At present, the most common high-risk circumstance for capacitative coupling is the use of monopolar RF instrumentation during single-port laparoscopic surgery. In this situation, an activated monopolar RF instrument is positioned alongside other shafted instruments (the laparoscope or grasping instruments), a circumstance that is ideal for the creation of a capacitor and therefore results in capacitative coupling. The usually uninsulated laparoscope is a common site for induction of this current.

Obviously, it would be desirable to have a system designed to handle the unique current-diversion issues that exist with monopolar RF instrumentation. One such system does exist and is designed for laparoscopic surgery: the Active Electrode Monitoring (AEM) system (Encision). This system has been available for many years and is designed to detect insulation defects and the presence of capacitative coupling in a way that deactivates the ESU should these conditions exist. Such a system is adaptable to most existing ESUs but requires the use of proprietary hand instruments that are available in a number of configurations. The protection is based upon the special outside sheath that detects an RF waveform "phase shift" that occurs when capacitative current is present on the instrument.

Preventing burns from ultrasound devices

Burns can occur with ultrasound-based devices, too. The narrow zone of coagulation makes direct extension an unlikely culprit. However, there is another mechanism that is well described but not very well known called "retained heat," a process whereby post–instrument-deactivation temperatures remain above the immediate "kill" temperature of 60°C. This process is present in both RF and ultrasound-based instrumentation. However, such heat is present for only a few seconds after deactivation of RF devices; in some circumstances, it can last up to 45 seconds or longer with ultrasonic scalpels or shears—a circumstance that places the patient at risk if the recently deactivated device comes in contact with tissue such as bowel or ureter before it cools. Understanding this potential, the surgeon should take care to avoid touching and retracting tissue with a laparoscopic ultrasonic system.

The most common high-risk circumstance for capacitative coupling is the use of monopolar RF instrumentation during single-port laparoscopic surgery

Take-home message

When energy-based surgical devices are properly applied, they provide useful assistance in vaginal, laparoscopic, laparotomic, and hysteroscopic procedures. However, improper use or poorly maintained instruments can lead to serious injuries. Familiarize yourself with any energy device used in surgical procedures, paying special attention to both proper handling and potential risks. ■

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Glossary of terms

Active electrode – In monopolar RF systems, the "active" electrode is designed to focus the energy on a concentrated area of tissue to achieve the desired tissue effect.

Capacitative coupling – the inducement of current through the intact insulation of the active electrode to surrounding cannulas or other instruments. Current that is capacitatively coupled seeks to complete the electrical circuit by finding an alternative pathway to the dispersive electrode on the patient. An electrical charge that is induced to surrounding cannulas or instruments is stored there until the generator is deactivated or a pathway to complete the circuit presents itself.

Current diversion – When using isolated-circuit monopolar RF systems, the entire patient is involved in the circuit. Thus, there is a potential for the diversion of current through any potential pathway, including that initiated by insulation defects or direct or capacitative coupling.

Dispersive electrode – In monopolar RF systems, the dispersive electrode, which has a relatively large surface area, is positioned on the patient to allow completion of the circuit without focusing the energy on the skin surface, thereby avoiding undesired burns.

Impedance – the degree to which the circuit or a portion of the circuit impedes the flow of electrons. Hydrated tissue that contains ions has low impedance, whereas dehydrated or desiccated tissue—or any tissue with lower ionic content—has higher impedance and, therefore, increased resistance to the flow of current.

Partial detachment – If there is partial detachment of the dispersive electrode, the current or power density increases, and the dispersive electrode can become active and capable of creating thermal injury. This problem is eliminated with most modern electrosurgical units by the use of "split-pad" technology, which detects partial or total separation of the dispersive electrode from the skin surface.

Piezoelectrode – From a surgical perspective, a piezoelectrode converts electrical energy into mechanical energy in the form of physical vibration. For ultrasonic surgical devices, this typically results in the oscillating activity that allows the tip of the ultrasonic device to vibrate in a linear fashion, about 50,000 times per second, and results in tissue effects that include vaporization and mechanical cutting as well as tissue coagulation and desiccation.

Retained heat – a process whereby the temperature of the device tip remains elevated after deactivation. To the extent that this temperature remains at or above 60ºC, contact with tissue can result in immediate cellular/tissue desiccation and coagulation. To a certain extent this phenomenon occurs with all RF and ultrasonic devices, but the latter retain the heat to a higher degree for a much longer time.

What to do with the vaginal apex at the time of hysterectomy

Optimal technique, tips, and tricks for successful vaginal closure of the cuff

Andrew I. Sokol, MD, and Katelyn R. Smithling, MD

Discussion of safety issues surrounding minimally invasive gynecologic surgery must include evidence-based technique for vaginal cuff closure at hysterectomy

Management of the vaginal cuff during hysterectomy remains an important consideration for gynecologists. In the short term, the main objective of cuff closure is to decrease bleeding and prevent cuff dehiscence and resultant evisceration. In the long term, the technique used for cuff closure may have implications for development of new or recurrent apical prolapse.

In this article, we review various techniques of vaginal cuff closure during open, laparoscopic, and vaginal hysterectomy, with particular focus on tips and tricks for successful closure of the cuff vaginally.

Choosing suture type and technique: Does it matter?

Prior to the advent of perioperative antibiotic prophylaxis, it was routine practice to leave the vaginal cuff partially open to allow for drainage. This is no longer necessary, and it is standard procedure to close the vaginal epithelium. Separate peritoneal closure is not necessary.

There is no evidence that a specific method of suture closure is superior to the others. The options for closure include continuous running, running-locked, or interrupted absorbable sutures.

Tips for suturing. During running cuff closure—particularly if it is being completed vaginally—we find it helpful to elevate the corners with long Allis clamps or stay sutures. This prevents "rolling in" of the vaginal epithelium and helps to ensure that the edges are correctly opposed during closure.

An inadequate purchase of the cuff during closure may increase the risk of vaginal cuff hematoma and resultant abscess; ensure full-thickness bites of the epithelium. If using a smaller caliber needle (such as an SH needle), it generally should be reloaded between the upper and lower edges of the incision to ensure an adequate purchase and to prevent bending of the needle.

To close from above or below during laparoscopic hysterectomy

Cuff dehiscence rates consistently are reported to be lower for vaginal and abdominal hysterectomy than for laparoscopic and robotic hysterectomy.[1-3] A recent review of reports of cuff dehiscence and vaginal

Dr. Sokol is Associate Professor of Obstetrics and Gynecology and Urology at Georgetown University School of Medicine and Associate Director, Minimally Invasive Surgery, Section of Female Pelvic Medicine and Reconstructive Surgery at MedStar Washington Hospital Center in Washington, DC.

Dr. Smithling is Clinical Fellow in Female Pelvic Medicine and Reconstructive Surgery at MedStar Washington Hospital Center.

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evisceration over 30 years found ranges of cuff dehiscence of 0.14% to 0.27% for all types of hysterectomy, and 1% to 4.1% after laparoscopic or robotic hysterectomy.[4] Authors of a recent meta-analysis of nearly 13,000 patients found a 3-fold and 9-fold reduction in cuff dehiscence with vaginal closure versus laparoscopic and robotic closure, respectively.[5]

Differences in surgical technique may account for the higher rates of cuff dehiscence with laparoscopic and robotic hysterectomy. Electrosurgery typically is used for creation of the colpotomy in laparoscopic and robotic hysterectomy, and thermal damage at the cuff could lead to poor healing. Experts generally recommend that cutting current, rather than coagulation current, be used for the colpotomy to minimize thermal spread.

One study attempted to address the impact of electrosurgery and laparoscopic suturing on the rate of vaginal cuff dehiscence by comparing the incidence of dehiscence in 463 patients undergoing total laparoscopic hysterectomy (TLH) for benign disease and 147 patients undergoing laparoscopic-assisted vaginal hysterectomy (LAVH) for cancer. In the TLH group, the colpotomy was created with an ultrasonically activated scalpel and closed with No. 2–0 polyglactin laparoscopically. In the LAVH group, the colpotomy was made with a monopolar electrosurgical pencil and closed with No. 0 polyglactin. There were no (0%) cases of cuff dehiscence in the LAVH group and 17 (4%) in the TLH group, suggesting that the increased magnification or laparoscopic suture technique, not electrosurgery, accounted for the increased incidence of dehiscence.[6]

Surgical tip: Avoid incorporating too little tissue when suturing. Increased magnification of the operative field during laparoscopic and robotic hysterectomy may result in unintentional incorporation of less tissue with each suture pass. When closing the cuff robotically or laparoscopically, we recommend reloading the needle between purchases of each cuff edge to ensure full incorporation of the tissue edges, especially since larger needles (CT-1) may not fit down the laparoscopic/robotic ports and are not usually utilized.

Barbed versus conventional sutures. Barbed suture material is purported to decrease the risk of cuff dehiscence with laparoscopic and robotic hysterectomy. In a retrospective analysis involving 387 women who underwent laparoscopic and robotic surgery, there were no cuff dehiscences in the 149 patients with laparoscopic barbed-suture cuff closure, compared with 10 of 238 (4%) with laparoscopic cuff closure with polyglactin, poliglecaprone 25, or an automated endoscopic suturing device.[7]

Authors of other studies, including a randomized controlled trial of 64 women undergoing TLH and a meta-analysis of 1,031 hysterectomies, have not found a difference in the rate of cuff dehiscence with barbed versus conventional suture.[8,9] Closure with barbed suture generally is faster compared with conventional suture material,[9] and is designed to result in equal distribution of tension across the vaginal cuff (though this is unlikely to be clinically significant). Barbed suture obviates the need to tie knots laparoscopically, a challenging and time-consuming skill, and is therefore appealing to many surgeons.

At present, there is insufficient evidence to claim the superiority of barbed suture over conventional suture, and the choice of which to use remains a matter of surgeon preference. If barbed suture is being used, however, patients should be counseled about the possibility of feeling the barbs, which may be palpable for several weeks.

Our bottom-line suture recommendations

Laparoscopic suturing is a highly advanced skill that many gynecologists do not master during residency training. In light of the current evidence, never hesitate to close the cuff from a vaginal approach, especially if you have any misgivings about laparoscopic suturing. If choosing to close the cuff laparoscopically, we recommend judicious use of electrocautery and care to incorporate at least 1 cm of tissue on each side of the vaginal cuff.

Closure of the cuff from a vaginal approach decreases the risk of cuff dehiscence 3-fold and 9-fold compared with laparoscopic and robotic closure, respectively

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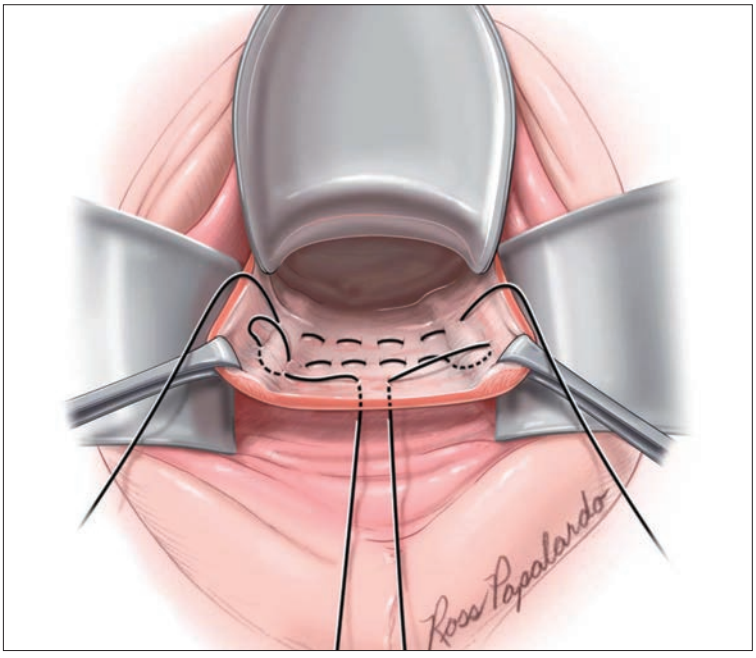
FIGURE 1 McCall culdoplasty for prevention of apical prolapse



McCall culdoplasty involves midline plication of the uterosacral ligaments with incorporation of the peritoneum and posterior vaginal cuff.

Preventing apical prolapse

Hysterectomy's impact on the development of subsequent apical prolapse remains a subject of debate. Hysterectomy has been found to be a risk factor for pelvic organ prolapse,[10,11] but some studies have found similar rates of prolapse in women with and without previous hysterectomy.[12,13] Women with prolapse at the time of their hysterectomy appear to be at increased risk for future prolapse surgery,[14,15] but few trials have evaluated surgical techniques for prevention of future prolapse in women without existing prolapse at the time of their hysterectomy. Techniques that have been evaluated for prolapse prevention typically have involved fixation of the cuff to the uterosacral ligaments.

McCall culdoplasty: The standard for women without prolapse at hysterectomy

The McCall culdoplasty is the most commonly performed technique for prevention of prolapse at the time of vaginal hysterectomy; it also may be performed from an abdominal approach. The McCall culdoplasty involves midline plication of the uterosacral ligaments with incorporation of the peritoneum and posterior vaginal cuff.

Technique. Traditionally, several rows of internal nonabsorbable sutures are placed, starting at the left uterosacral ligament, then incorporating the peritoneum of the cul-de-sac, and ending in the right uterosacral ligament (**FIGURE 1**). These sutures obliterate the cul-de-sac and help prevent future enterocele formation.

External sutures are also placed; these incorporate the vaginal epithelium, muscularis, and uterosacral ligament on one side, then travel across the cul-de-sac peritoneum, and exit through the contralateral uterosacral ligament and vaginal cuff. The external sutures elevate the posterior vagina to the uterosacral ligaments and thereby add vaginal length. Some surgeons simplify this technique by omitting the internal sutures.

See the **VIDEO**, "McCall culdoplasty technique," by Mickey Karram, MD, that accompanies this supplement at http://obgmanagement.com.

The evidence. To date, there is only 1 trial comparing techniques of cuff closure during vaginal hysterectomy to prevent future prolapse in women without preexisting prolapse. This trial compared McCall culdoplasty, simple purse-string closure of the peritoneum, and vaginal Moschcowitz-type closure (which involves purse-string closure of the posterior peritoneum with fixation to the distal uterosacral and cardinal ligaments) in 100 women undergoing hysterectomy.[16] The investigators found a significantly lower incidence of stage 2 pelvic organ prolapse (descent to within 1 cm of the hymen) at 3 years after hysterectomy for McCall culdoplasty (2/32 [6%]) versus peritoneal closure (13/33 [39%]) and vaginal Moschowitz procedure (10/33 [30%]) ($P = .004$).

Our recommendation. Given the safety and ease of McCall culdoplasty, we recommend that this procedure be performed as part of all hysterectomies in women without prolapse.

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McCall culdoplasty technique

Mickey Karram, MD

View the video with this supplement posting in the Education Center at **obgmanagement.com**

Courtesy of Mickey Karram, MD, International Academy of Pelvic Surgery

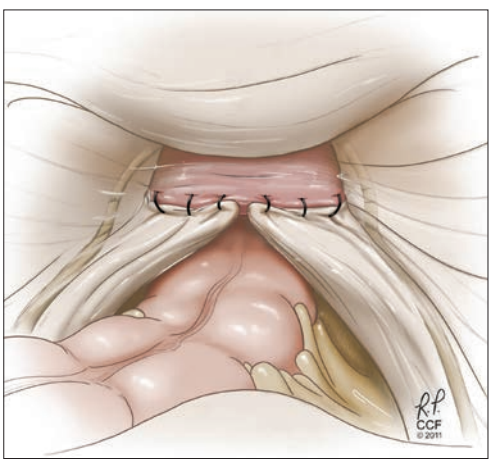
Modify the McCall if there is prolapse at hysterectomy

In women with uterovaginal prolapse, modification of the McCall culdoplasty with fixation to a higher portion of the uterosacral ligament improves the durability and success of apical suspension.

In this procedure, the proximal uterosacral ligaments are identified by placing traction on the distal portion of the ligaments at their insertion into the vaginal cuff. The proximal ligament is grasped with an Allis clamp and deviated away from the pelvic sidewall. Two or 3 nonabsorbable or delayed-absorbable sutures are placed through the ligament and then affixed to the anterior and posterior vaginal cuff (**FIGURE 2**). These sutures affix the uterosacral ligaments to the pubocervical and rectovaginal muscularis, thereby reestablishing the connections between upper vaginal supports. If using permanent sutures, the vaginal epithelium is excluded. The sutures are tied down, elevating the cuff to the proximal uterosacral ligaments.

Place lateral stay suture(s) or Allis clamps(s) at the corners of the cuff to delineate the full incision

FIGURE 2 Abdominal view of modified (high) McCall culdoplasty



For women with uterovaginal prolapse at the time of hysterectomy, fixating the McCall culdoplasty to a higher portion of the uterosacral ligament improves apical suspension.

The success rate for this technique is approximately 80%.[17] The main concern with this procedure is ureteral injury, due to the close proximity of the ureters to the uterosacral ligaments. Ureteral kinking by the uterosacral suspension suture, rather than ligation or transection, may occur in up to 1% to 11% of cases,[18,19] and is easily corrected by simple release of the suture. While not the focus of this article, we suggest cystoscopy to ensure ureteral patency when any vault suspension technique is utilized.

Surgical tip. It can be quite challenging to close the cuff after it has been suspended. You may find it helpful to partially close the cuff by placing a few running sutures from each angle and holding them prior to tying down the suspension sutures, then complete the cuff closure with the held sutures after tying the suspension sutures.

Final takeaways, from evidence and experience

Though it is often overlooked, the technique for closure of the vaginal cuff can have a major impact on the outcome of hysterectomy. Performing a McCall culdoplasty at the time of vaginal hysterectomy has been shown to prevent future apical prolapse and adds minimal time to the procedure. It is reasonable to presume that reattaching the vaginal cuff to the uterosacral ligaments during other routes of hysterectomy would have a similar protective effect. In addition, data indicate that closure of the cuff from a vaginal approach results in less cuff dehiscence than laparoscopic and robotic approaches. Surgeons should strongly consider a vaginal approach to cuff closure, especially if they have any misgivings about laparoscopic suturing. ■

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Will computer-assisted surgery shake the foundations of surgical ethics in the age of patient-centered medicine?

Teleoperators and virtual reality simulators combine to offer a solution to the moral dilemma surrounding surgical training

Antonio R. Gargiulo, MD

Advances in computer-assisted surgery have the ability to improve surgeon training and patient safety

Nobody is born a surgeon, or a violin virtuoso. Great coaching and an indefatigable commitment to self-improvement are required to reach professional excellence.[1] A violinist will practice thousands of hours to achieve a flawless performance, just as a surgeon may have to operate thousands of hours to reach consistent proficiency.[2] The violinist trains on an inanimate instrument, but the surgeon must do so on human beings (one less imperfect execution at a time). This is the unspoken necessary evil at the core of surgery: we spend a lifetime in the pursuit of perfection, and the operating room is both our theatre and our training grounds. Our patients must relinquish some amount of safety for the better good of the human family at large so that the art of surgery can be passed from the more experienced to the less experienced practitioners and be available for future generations.

To be sure, modern surgical training in America is a safe and marvelously self-sustaining reality, envied the world-over, and built on the vision of medical pioneers at the turn of the 20th Century. Among these pioneers is William S. Halsted, promoter of the structured residency program in which surgeons could train under expert supervision, with gradual independence gained through outstanding performance. Halsted's reinterpretation of surgical training was centered on patient safety rather than on surgeon convenience. Indeed, his surgical residency program was designed to last a full 10 years!

Halsted is credited with innovations in the fields of asepsis, analgesia, and anesthesia. His contributions were aimed at improving not only the surgical outcome but also the patients' experience. Halsted was an *ante litteram* advocate of patient-centered medicine.[3] This tradition of modifying the practice of surgery in order to meet our patients' needs, to reduce their suffering and to make their experience more dignified, has continued with the development of minimally invasive surgery.

The changes in the field of gynecologic surgery during my generation have been particularly dramatic. I, for example, am a classically trained surgeon but have not performed open surgery in over a decade. Scientific evidence persuaded me long ago that minimally invasive surgery offers vastly superior clinical outcomes compared with open surgery, and therefore constitutes a patient's right in any developed country. Exceptions to this rule should be pathology related, not operator related.

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Dr. Gargiulo is Assistant Professor of Obstetrics, Gynecology and Reproductive Biology at Harvard Medical School in Boston, Massachusetts, and Medical Director of the Center for Robotic Surgery at Brigham and Women's Hospital, Boston.

Dr. Gargiulo reports being a consultant to Kawasaki Robotics (USA), Inc. and OmniGuide, Inc.

"Knowing an injury could occur, I had to take the next step to ensure patient safety."

I switched over from conventional monopolar laparoscopy to AEM® Burn Protection Technology after my second experience with a stray energy burn to one of my patients. I was operating on a 30-year old nurse, someone who knew me professionally and trusted my capabilities. We performed the outpatient laparoscopic cholecystectomy without any issues, it all went smoothly. Three days later the patient came to our ER septic and with generalized peritonitis. An open surgery was required, and that's when I discovered a hole near the cecum, way out of the initial surgical field. After resecting the patient's small bowel, we ordered pathology and the report was consistent with a burn injury.

The laparoscopic equipment was inspected by the hospital engineers and by the equipment manufacturer. Both parties confirmed there were no insulation breakdowns. We were certain we were dealing with a stray energy burn caused by capacitive coupling.

Our patient eventually did fine, but suffered through the heartache of being gravely ill. The patient required a second surgery, a lengthy hospital admission with a 10-day ICU stay, and a 4-month absence from work. Because I was honest about what was happening, explaining that the burn injury was a rare complication of laparoscopy, the patient didn't file any medico-legal action against the hospital or me. However, I believe there was a suit filed against the equipment manufacturer.

When I saw how AEM Burn Protection Technology eliminated stray energy burns in laparoscopy, I was an instant believer. The new AEM EndoShield® "plug-and-play" is great; it's the same safe technology, the same high quality instruments, but EndoShield is easier for our perioperative staff to set up. Everyone benefits from having AEM on board—the hospital, the patients and all the surgeons who practice there.

My two experiences with stray energy burns have been haunting. My patients trusted me, and this happened despite my skill and expertise. I'm more confident when I use AEM during monopolar cautery. I know I won't experience a stray energy burn; I'm protecting my patient from unintended injury. Knowing that it's very possible an injury can occur, I couldn't justify not taking the next step to ensure patient safety.

It's every doctor's intention to ensure patient safety. In my opinion, even if you are skeptical about the possibility of stray energy burns, why not try the AEM technology: it's comparably priced, the instruments are high quality/high performing, and the system is transparent to the OR team...why not try it and feel confident? You have nothing to lose.

"Despite the many years of conversation regarding stray energy burns, physicians still have little understanding of how these injuries can occur during laparoscopy. Our take-away has always focused on inspecting for insulation breakdowns. Very little has been explained about capacitive coupling and the fact that injury could occur despite intact equipment."

Craig Hornbarger, MD, FACS
General Surgeon
Sky Ridge Medical Center
Lone Tree, CO

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FIGURE 1. Virtual learning curve

Every point in the learning curve represents an individual, not just an operation. Ideally, every individual has a right to enter care at the top of the curve. Current technology challenges all surgeons to achieve this goal.

Teleoperators and virtual reality simulation can eliminate the "rookie effect" of surgical training

Minimally invasive is the here and now

If we agree that the gold standard surgical technique is the one associated with less tissue trauma, fewer complications, less pain, and lower cost to society, then the standard for every gynecologic surgery is its minimally invasive version. All surgeons do not need to agree on this point because the minimally invasive approach is what informed patients expect of modern surgery, and patient-centered outcome research is poised to become the driving force of sustainable health care.[4]

Unfortunately, the new standard is harder to learn and perform. For gynecologists, this involves developing hand-eye coordination skills to offset the ergonomic challenges of working through a fulcrum in a bidimensional world (laparoscopy). Alternatively, for more limited applications, we must learn to work inside a small cylinder with a blinded assistant (vaginal surgery).

The learning curve is a challenge

Let us recapitulate. Minimally invasive surgery is a patient's right. It is hard to learn, however, hence harder to teach through the classic Halstedian model. Exemplifying this concept is a recent study comparing the follicular damage following the laparoscopic excision of ovarian endometrioma by attending versus resident physicians. Not surprisingly, the trainees lost a significantly higher number of eggs.[5]

Observations such as these bring to the forefront the questionable ethical base of the surgical learning curve. The learning curve is a reality. Rookies make more mistakes than seasoned players, and everybody is a rookie again when when the rules of the game change radically. It now appears that the rules have changed: gynecologic surgeons who perform the majority of their operations by open surgery may no longer thrive. This change does not come down from committees or governing bodies. The change is based on the radical and irreversible reality that medical knowledge is on the Internet. Patients have access to it, and they use it to make decisions that make sense to them.

Can we shorten the learning curve?

How will we train ourselves through this epochal transition? We need to ensure that patients will still have access to capable providers but do not have to sustain the "rookie effect" of a massive number of providers who will be thrown back in the learning curve. For laparoscopy (alas, not for vaginal surgery) there is evidence that the meaningful learning curve could be shortened—and eventually eliminated—with the help of 2 aspects of computer-assisted surgery that benefit surgeons in complementing ways: teleoperators and virtual reality simulators (**FIGURE 1**).

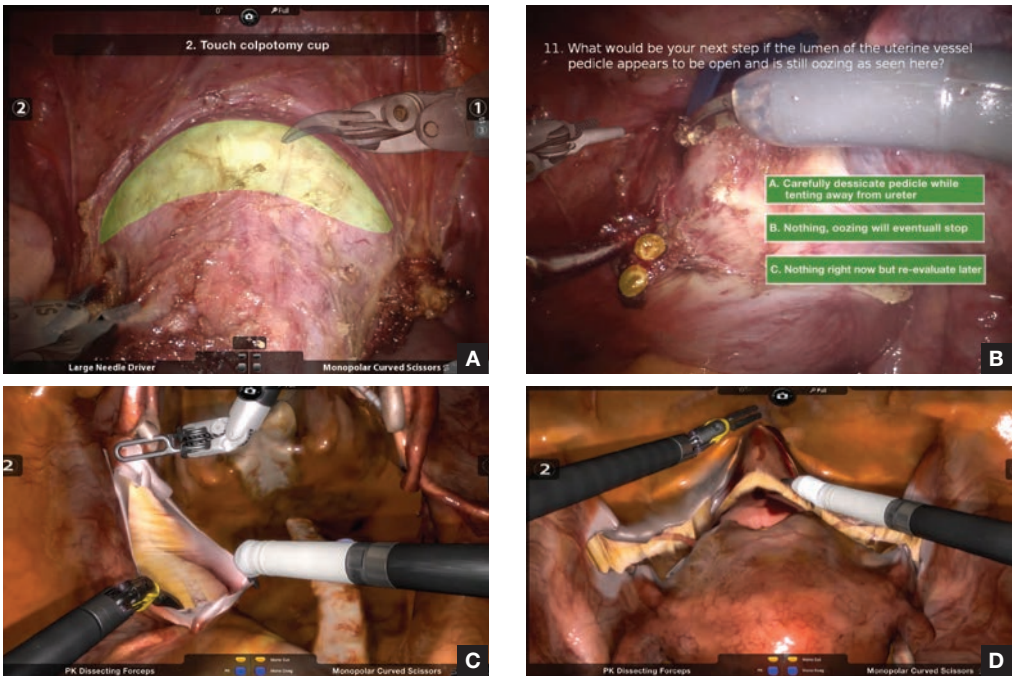
Teleoperators

The teleoperator serves as the physical interface between the eyes and limbs of the surgeon and the ergonomic challenges of laparoscopy, which include[6]:

- inverted pitch and yaw of the instruments (due to the fulcrum effect)
- absent pitch and yaw at the wrist

PHOTO ILLUSTRATION: JOHN DENAPOLI FOR OBG MANAGEMENT

FIGURE 2. Computer-assisted virtual reality



Virtual simulation advances provide anatomically accurate surgical environments that promote a shortened learning curve and patient safety.
Illustrations: Used with permission from Mimic (A and B) and Simbionix (C and D).

- loss of stereoscopic view
- visual disconnection (the operator looks away from the field)
- significant postural strain.

The teleoperator makes laparoscopy feel, quite ironically, more natural. Studies demonstrating the enabling nature of teleoperators abound.[7] An enabling tool, however, needn't be easy to use. Teleoperators have their own limitations and present the surgeon with new and unfamiliar challenges. A simile that comes to mind is that of the modern off-road vehicle. If you know how to use it, it will reliably take you places that you could not otherwise easily reach; if you do not know how to use it, it may well become your grave.

Virtual reality

This is where virtual reality simulation closes the safety loop and makes computer-assisted surgery a realistic solution to our moral conundrums with surgical training. Due to the fact that this type of surgery is performed at a console, the simulated working conditions are identical to those found in the real operation.

The field of computer-assisted surgery is strongly invested in simulation, which will become, in my opinion, the ultimate differentiator (**FIGURE 2**). The teleoperator renders laparoscopy ergonomic, and the simulator helps the surgeon become one highly functional entity with the teleoperator. The result is a seamless integration of man and machine that creates a technical equalizer and promotes consistently high technical performance. Paradoxically, it is through the most artificial of means that surgery is going back to basics: tool in hand, technical barriers eliminated, and success gained with knowledge and good sense.

Integration of man and machine allows surgery to go "back to basics"

Recent evidence validates simulation tools

The predicted validity of digital simulation on subsequent surgical proficiency in robotic hysterectomy has been established

recently by Culligan and colleagues.[8] In their study, first, robotic-naïve surgeons were required to surpass the score levels previously established by expert robotic surgeons on commercially available simulation software on the robotic console. This was no easy task: the console training lasted 20 hours on average. Next, the robotic-naïve surgeons performed their very first human robotic hysterectomy. Perioperative and operative outcomes were compared with those of 2 control groups: expert robotic surgeons and practicing robotic surgeons (at the same institution). The investigators found that study surgeons performed at a level comparable to that of the expert surgeons, and at a significantly higher level than that of the other credentialed surgeons at their institution.

These findings are humbling, and should make us all (technophiles and technophobes) reflect on the fact that we now have validated tools that can shorten the learning curve of minimally invasive surgery. The work by Culligan and colleagues is now included in the resident and fellow training pathway at Brigham and Women's Hospital, as well as in obtaining and maintaining robotic certification priviledges, in select cases.

Of course, simulation cannot make up for real-life experience. Surgical mastery is more than exceptional dexterity. It is the anticipation of clinical scenarios and the ability to respond in the most effective way. Dexterity reached through a patient-friendly learning curve is what computer-assisted surgery offers to surgeons today. It is only a starting point, but a good one indeed.

"Why should a 'see one, do one, teach one' attitude still have a place in modern medicine?"
—Antonio R. Gargiulo, MD

When Captain Chesley Sullenberger experienced simultaneous power loss in both engines on US Flight 1549, he had just 3 minutes to consider several emergency options and nail the perfect crash landing on the Hudson River—not fast enough to risk a flip, not slow enough to risk a stall. He even remembered to activate the aircraft's "ditching" button, sealing the plane from water intake. Sullenberger had literally "been there before," thanks to the fastidious attention to virtual reality simulation requirements that the Federal Aviation Administration imposes on commercial pilots.

The question therefore is: If our operating tool becomes a computer, what makes us surgeons different from aviation professionals when it comes to training standards? Why should a "see one, do one, teach one" attitude still have a place in modern medicine?

Safe surgical training can become a "virtual" reality

One can only wonder what Professor Halsted himself would say about all this, and how he would choose to integrate the modern tools at our disposal to bring surgical training to yet another level of safety. Judging by his teaching philosophy, my guess is that he would have looked at computer-assisted surgery, where one can "simulate a hundred times" and only then, "do one," as the only ethical way forward. In a not so distant future, technical training of surgeons on people (or animals) may be considered a necessary evil that did not survive the information age. ■

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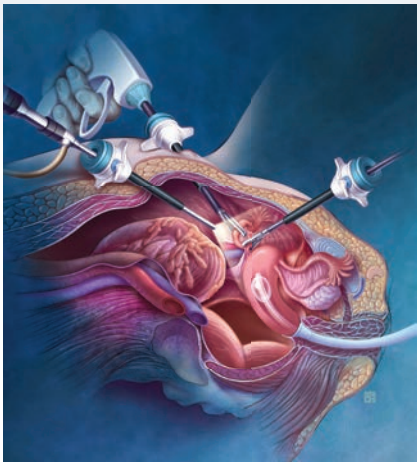

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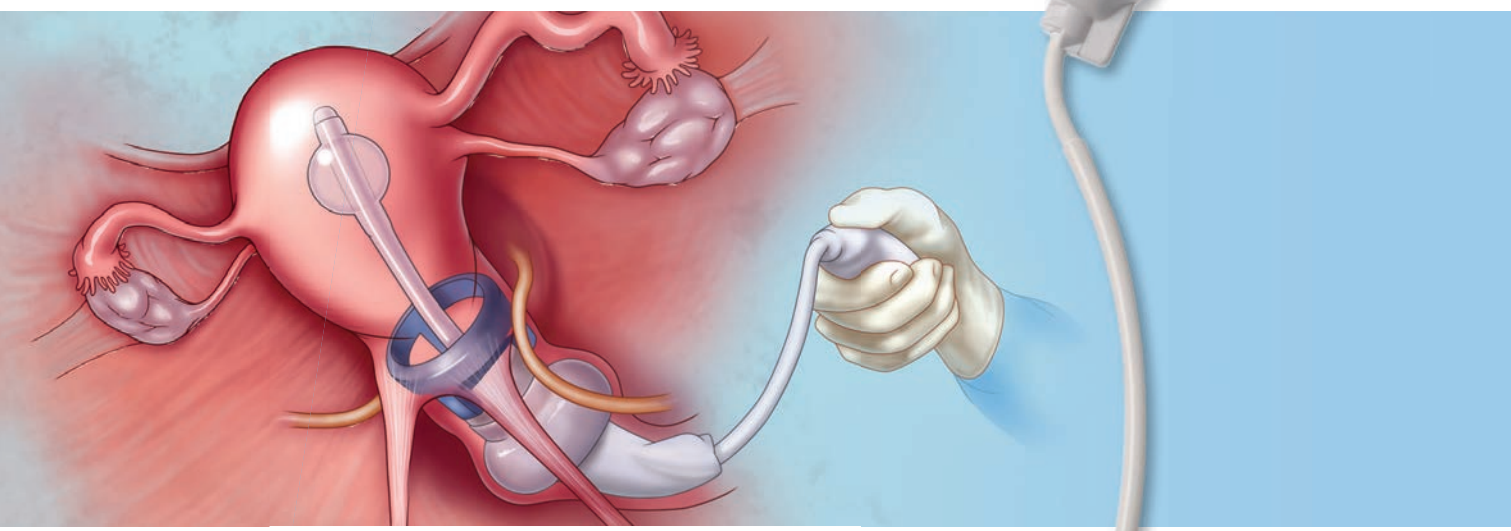

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