MINIMALLY INVASIVE GYNECOLOGIC SURGERY

High-tech advances in gynecologic surgery have created a need for high-tech training of surgical trainees. Taking a cue from aviation training, gynecologic surgery has developed various simulation training strategies to engage trainees in an active, experiential process that produces surgical skill proficiency.

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Gynecologic surgeons who trained in the early 1990s may feel that the practice of gynecologic surgery seemed simpler back then. There were really only 2 ways to perform a hysterectomy: vaginally (TVH—total vaginal hysterectomy) and abdominally (TAH—total abdominal hysterectomy). Global endometrial ablation devices were not an established treatment for abnormal uterine bleeding, and therapeutic advancements such as hormonally laden intrauterine devices, vaginal mesh kits, and surgical robots did not exist. The options in the surgical toolbox were limited, and the general expectation in residency was long hours. During that period, consistent exposure to the operating room and case volume allowed one to graduate confidant in one's surgical skills.

The changing landscape of gynecologic surgery

Fast-forward to 2017. Now, so many variables affect the ability to produce a well-trained gynecologic surgeon. In fact, in 2015 Guntupalli and colleagues studied

the preparedness of ObGyn residents for fellowship training in the 4 subspecialties of female pelvic medicine and reconstructive surgery, gynecologic oncology, maternal-fetal medicine, and reproductive endocrinology-infertility.[1] Through a validated survey of fellowship program directors, the authors found that only 20% of first-year fellows were able to perform a vaginal hysterectomy independently, and 46%, an abdominal hysterectomy. Barely 50% of first-year fellows in all subspecialties studied could independently set up a retractor for laparotomy and appropriately pack and mobilize the bowel for pelvic surgery.[1]

Today the hysterectomy procedure has become the proverbial alphabet soup. Trainees are confronted with having to learn not only the TVH and the TAH but also the LAVH (laparoscopic-assisted vaginal hysterectomy), LSH (laparoscopic supracervical hysterectomy), TLH (total laparoscopic hysterectomy), and RALH (robot-assisted laparoscopic hysterectomy).[2] With a mandated 80-hour residency workweek restriction and an increasing number of minimally invasive hysterectomies performed nationally, a perfect storm exists for critically evaluating the current paradigm of resident and fellow surgical training.[3]

One may wonder if current controversies surrounding many of the technologic advancements in gynecologic surgery result from inadequate training and too many treatment options or from flaws in the actual devices. A "see one, do one, teach one" approach to assimilating surgical skills is no longer an accepted approach, and although the "10,000-hour rule" of focused practice to attain expertise makes sense, how can a trainee gain enough exposure to achieve competency?

Simulation: A creditable training tactic

This is where simulation—whether low or high fidelity—potentially can fill in some of those training gaps. Simulation in medicine is a proven instructional design strategy in
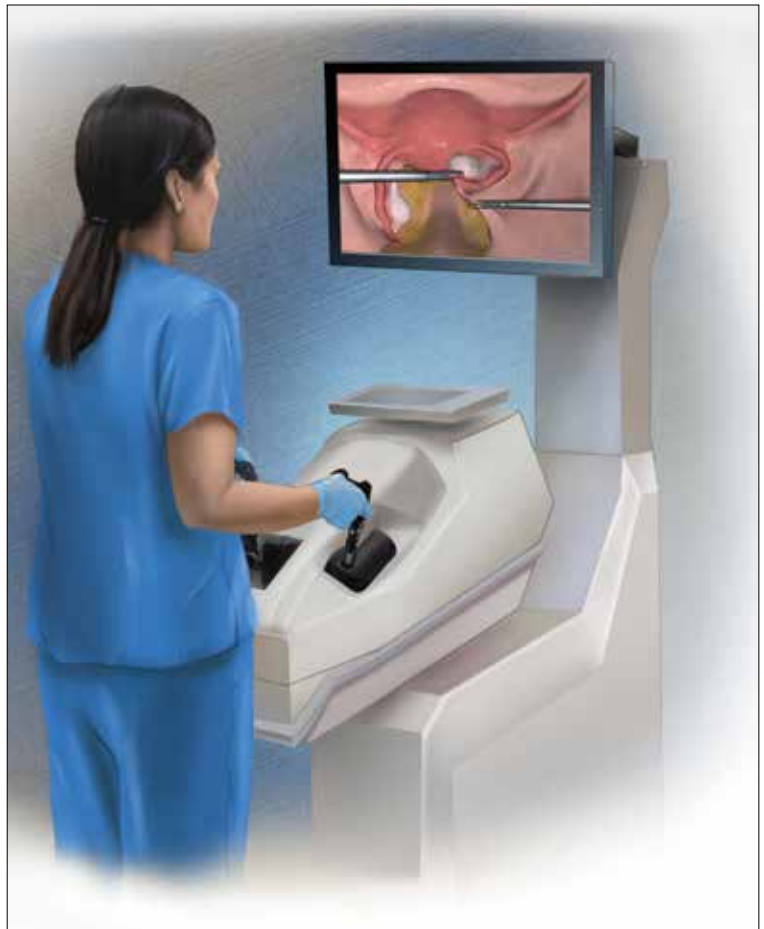
A student trains on a high-fidelity simulator to improve technique in laparoscopic adnexal surgery.

which learning is an active and experiential process. Studies clearly have shown that simulation-based medical education (SBME) with deliberate practice is superior to traditional clinical medical education in achieving specific clinical skill acquisition goals.[4]

This special Update on minimally invasive gynecologic surgery offers a 30,000-foot overview of the current state of simulation in gynecologic surgical training. Equally important to this conversation is the process by which a trained individual can obtain the appropriate credentials and subsequent privileging to perform various surgical procedures. Simulation has begun to play a significant role not only in an individual's initial credentialing and privileging in surgery but also in maintaining those privileges.

Simulation's evolving role in gyn surgery training

Recently, the traditional model of gynecologic surgical training has been impacted by the exponential growth of technology (surgical devices), increased surgical options, and the limited work hours of trainees. As a result, simulation-based medical education has been identified as a potential solution to address deficits in surgical training. Fortunately, all modalities of surgery are now amenable to improvements in surgical education via simulation.[5]

Although basic skill training in the standard areas of hand-eye coordination, tissue handling, and instrument use still is prerequisite, the integration of both low- and high-fidelity simulation technologies—with enhanced functionality—now allows for a more comprehensive approach to understanding surgical anatomy. In addition, simulation training provides the opportunity for independent practice of full surgical procedures and, in many instances, offers objective and instantaneous assessment feedback for the learner. This discussion highlights some of the relevant literature on simulation training and the impact of surgical simulation on hysteroscopy and laparoscopy.

Box trainers and virtual reality simulators in hysteroscopy training

Hysteroscopic surgery allows direct endoscopic visualization of the uterine cavity for both diagnostic and therapeutic purposes. While the majority of these procedures are generally low risk, operative hysteroscopic experience minimizes the possibility of significant procedure-related complications, such as uterine perforation.[5] The literature repeatedly shows that significant differences exist in skill and sense of preparedness between the novice or inexperienced surgeon (resident trainee) and the expert in hysteroscopic surgery.[6–8]

Both low- and high-fidelity hysteroscopic simulators can be used to fine-tune operator skills. Low-fidelity simulators such as box trainers, which focus on skills like endometrial ablation and hysteroscopic resection with energy, have been shown to measurably improve performance, and they are well-received by participants. Low-fidelity simulations that incorporate vegetable/fruit or animal models (for example, porcine bladders and cattle uteri) have also been employed with success.[9]

On the high-fidelity end, surgical trainees can now experience hysteroscopic surgery simulation through virtual reality simulators, which have evolved with improvements in technology (**FIGURE 1**). Many

FIGURE 1 **Hysteroscopic surgical simulation**
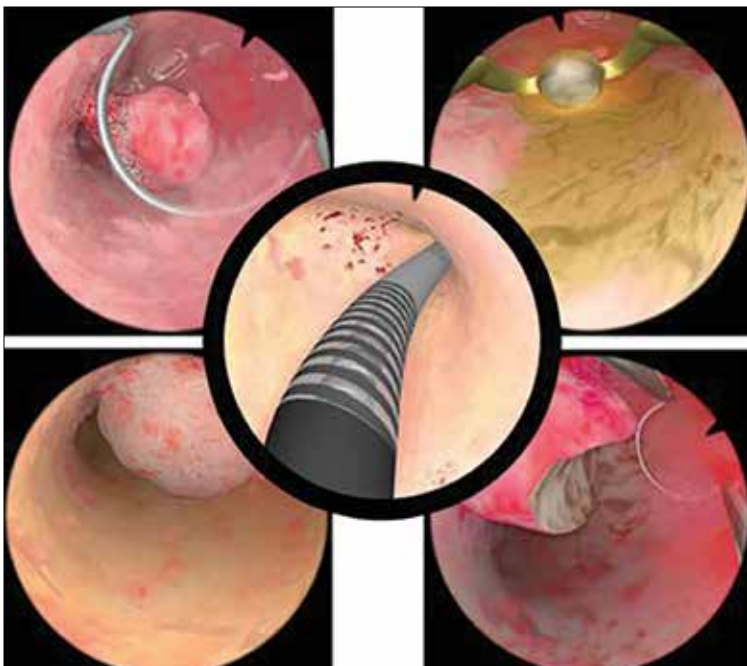
Five examples of varying pathology are available in hysteroscopic simulation by the HYST Mentor simulator: upper left-hand side, polypectomy; upper right-hand side, rollerball endometrial ablation; lower left-hand side, identification of a submucosal myoma; lower right-hand side, myomectomy; center image, sterilization.

Used with permission from 3D Systems, Littleton, Colorado.

high-fidelity simulators have been developed, and technical skill and theoretical knowledge improve with their use. Overall, trainees have provided positive feedback regarding the realism and training capacity afforded by virtual reality simultors.[10,11]

Various simulators are equipped with complete training curriculums that focus on essential surgical skills. Common troubleshooting techniques taught via simulator include establishing and maintaining clear views, detecting and coagulating bleeding sources, fluid management and handling, and instrument failure. Learners can perform these sessions repeatedly, independent of their respective starting skill level. On completion of simulation training, the trainee is given objective performance assessments on economy of motion, visualization, safety, fluid handling, and other skills.

Learning the complexities of laparoscopy through simulation

Laparoscopic surgery (both conventional and robot assisted) allows for a minimally invasive, cost-effective, and rapid-recovery approach to the management of many common gynecologic conditions. In both approaches, the learning curve to reach competency is steep. Conventional laparoscopy requires unique surgical skills, including adapting to a 2-dimensional field with altered depth perception; this creates challenges in spatial reasoning and achieving proficiency in video-eye-hand coordination as a result of the fulcrum effect inherent in laparoscopic instrumentation. This is further complicated by the essential dexterity required to complete dissections and suturing.[12,13]

Robot-assisted laparoscopic surgery requires significant modifications to adapt to a 3-dimensional view. In addition, this approach incorporates another level of complexity (and challenge to attaining mastery), namely, using remotely controlled multiple instrument arms with no tactile feedback.

Importantly, some residency training programs are structured unevenly,

FIGURE 2 Laparoscopic simulators

Examples of 2 low-fidelity laparoscopic simulators, the FLS Trainer Box, **left** (Limbs & Things, Savannah, Georgia), and the SimSei Laparoscopic Trainer, **right** (Applied Medical, Rancho Santa Margarita, California).

emphasizing one or the other surgical modality.[14] As a result, this propagates certain skills—or lack thereof—on graduation, and thus highlights potential areas of laparoscopic training that need to be improved and enhanced.

Increasing the learning potential

The growing integration of low- and high-fidelity simulation training in laparoscopic surgery has led to improved skill acquisition.[12,13,15,16] A well-established low-fidelity simulation model is the Fundamentals of Laparoscopic Surgery module, through which trainees are taught vital psychomotor skills via a validated box trainer that is also supported by a cognitive component (**FIGURE 2**).[17,18]

The advent of laparoscopic virtual reality training systems has raised the learning potential further, even for experienced surgeons. Some benefits of virtual reality simulation in conventional laparoscopy include education on an interactive 3D pelvis, step-by-step procedural guidance, a comprehensive return of performance metrics on vital laparoscopic skills, and the incorporation of advanced skills such as laparoscopic

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Laparoscopic virtual reality training has raised the learning potential, even for experienced surgeons

FIGURE 3 **Laparoscopic surgery simulator**
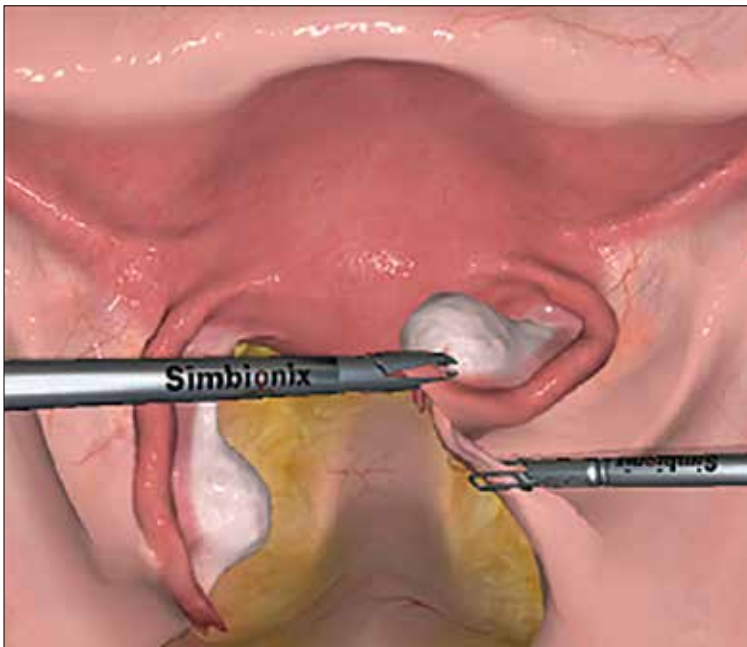
The LAP Mentor provides simulation of adnexal surgery.
Used with permission from 3D Systems, Littleton, Colorado.

suturing, complex dissections, and lysis of adhesions.

In the arena of robot-assisted procedures, simulation modules are available for learning fundamental skill development in hand-eye coordination, depth perception, bimanual manipulation, camera navigation, and wrist articulation.

In both conventional and robot-assisted laparoscopy simulation pathways, complete procedural curriculums (for example, hysterectomy with adnexectomy) are available. Thus, learners can start a procedure or technique at a point applicable to them, practice repeatedly until competency, and eventually become proficient (**FIGURE 3**).

Generally, high-fidelity computerized simulators provide a comprehensive performance report on completion of training, along with a complete recording of the trainee's encounter during accruement of skill. Most importantly, laparoscopic training via simulation has been validated to translate into improved operating room performance by impacting operating times, safety profiles, and surgical skill growth.[15,19]

Simulation is a mainstream training tool

The skills gap between expert surgeons and new trainees continues to widen. A comprehensive educational pathway that provides an optimistic safety profile, abides by time constraints, and elevates skill sets will fall to simulation-based surgical training.[20,21] Surgical competence is defined not simply by observation and Halstedian technique but by a combination of cognitive and behavioral abilities as well as perceptual and psychomotor skills. It is impractical to expect current learners to become proficient in visuospatial and tactile perception and to demonstrate technical competency without supplementing their training.[22-24] Ultimately, as experience with both low- and high-fidelity surgical simulation grows, the predictive validity of this type of training pathway will become more readily apparent. In other words, improved performance in the simulated environment will translate into improved performance in the operating room.

Incorporating gyn surgery simulation into credentialing and privileging

Over the last 25 years surgeons have seen unprecedented changes in technology that have revolutionized our surgical approaches to common gynecologic conditions. In the past, granting surgical privileges was pretty straightforward. Surgeons were granted privileges based on successfully completing their training, and subsequent renewal of those privileges was based on not having any significant misadventures or

complications. With the advent of laparoscopy, hysteroscopy, and then robot-assisted surgery, training surgeons and verifying their competency has become much more complicated. The variety of surgical approaches now being taught coupled with reduced resident training time and decreasing case volumes have significantly impacted the traditional methodologies of surgical training.[25,26]

High-tech surgery demands high-tech training

The development of high-tech surgical approaches has been accompanied by the natural development of simulation models to help with training. Initially, inanimate models, animal labs, and cadavers were used. Over the last 15 years, several innovative companies have developed virtual reality simulation platforms for laparoscopy, hysteroscopy, and even robotics.[27] These virtual reality simulators allow students to develop the psychomotor skills necessary to perform minimally invasive procedures and to practice those skills until they can demonstrate proficiency before operating on a live patient.

Most would agree that the key to learning a surgical skill is to "practice, practice, practice."[28] Many studies have shown that improvement in surgical outcomes is clearly related to a surgeon's case volume.[29,30] But with case volumes decreased, simulation has evolved as the best training alternative. Current surgical simulators enable a student to engage in "deliberate practice"; that is, to have tasks with well-defined goals, to be motivated to improve, and to receive immediate feedback along with opportunities for repetition and refinements of performance.

Simulation allows students to try different surgical techniques and to use "deliberate practice" avoidance of errors in a controlled, safe situation that provides immediate performance feedback.[31] Currently, virtual reality simulators are available for hysteroscopy, laparoscopy, and robot-assisted gynecologic applications. Early models focused solely on developing a learner's psychomotor skills necessary to safely perform minimally invasive surgeries. Newer simulators add a cognitive component to help students learn specific procedures, such as adnexectomy and hysterectomy.[32]

Based on the aviation simulator training model, the AAGL endorsed a Gynecologic Robotic Surgery Credentialing and Privileging Guideline in 2014; this guidance relies heavily on simulation for initial training as well as for subsequent annual recertification.[33] Many institutions, including the MultiCare Health System in Tacoma, Washington, require all surgeons—even high-volume surgeons—to demonstrate proficiency annually by passing required robotic simulation exercises at least 2 times consecutively in order to maintain robotic surgery privileges.[34]

A work-around for a simulation drawback

Using simulation for recertification has been criticized because, although it can confirm that a surgeon is skilled enough to operate the tool, it does not evaluate surgical judgment or technique. In response, crowdsourced review of an individual surgeon's surgical videos has proven to be a useful, dependable way to give a surgeon direct feedback regarding his or her performance on a live patient.[35] Many institutions now use this technology not only for initial training but also for helping surgeons improve with direct feedback from master surgeon reviewers. Other institutions have considered replacing annual re-credentialing case volume requirements with this technology, which actually assesses competence in a more accurate way.[36]

A new flight plan

The bottom line is that the training and annual recertification of future surgeons now mimics closely the pathway that all airplane pilots are required to follow.

Initial training will require mastery of surgical techniques using a simulator before taking a "solo flight" on a live patient.

Maintenance of privileges now requires either large case volumes or skills testing

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on a simulator. Many institutions now also require an annual "check ride," such as a crowdsourced video review of a surgeon's cases, as described above.

Re-credentialing. Just as the "see one, do one, teach one" model is now part of our historical legacy, re-credentialing simply by avoiding misadventures and staying out of trouble will go the way of paper medical records. Our future will certainly require an annual objective evaluation of good surgical judgment and surgical technique proficiency. Surgical simulation will be the norm for all of us. ⊘

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