

Need to hone your surgical skills? Think simulation

🔴 Simulation-based training doesn't have to feature the latest in virtual reality to have a genuine effect on your skills and confidence as a surgeon and your ability to work on a team

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In the September 2008 issue of OBG MANAGEMENT, the authors looked at how simulation can train, and refresh, physicians for critical obstetric events. Available at obgmanagement.com

More than 32 million surgical procedures were performed in the United States in 2006.¹ And because that number is still on the rise, the rate of surgical mishap is likely to increase, as well.

Is proctorship of real cases enough to ensure the competency of the surgeons and surgical trainees who will be performing these procedures?

Many experts look toward simulation-based training as a credible means by which surgeons can sharpen old skills, learn new ones, and promote safe care of surgical patients. In this article, we discuss the use of simulators to facilitate the acquisition and maintenance of skills in minimally invasive surgery, including current and anticipated applications in the field of gynecology, focusing on:

- acquisition of laparoscopic skills
- assessment of the level of expertise of trainees and experts alike
- transfer of skills to the operating room (OR)
- development of teamwork
- utility in the credentialing process.

Simulation will never completely replace supervised learning on real patients, of course. Nevertheless, it is time to move beyond reliance solely on apprenticeship in obstetrics and gynecology. Considerable evidence supports simulation as a safe, practical way for clinicians to acquire and maintain procedural and team skills. It may also facilitate the assessment of competency in the credentialing process and reduce errors and adverse events.

Roxane Gardner, MD, MPH

Dr. Gardner is Assistant Professor of Obstetrics, Gynecology, and Reproductive Biology at Harvard Medical School and Associate Obstetrician and Gynecologist at Brigham and Women's Hospital in Boston. She also serves on the faculty of the Center for Medical Simulation in Cambridge, Mass.

Robert Gherman, MD

Dr. Gherman is Assistant Clinical Professor at Uniformed Services University of the Health Sciences in Bethesda, Md, and Head of the Division of Maternal-Fetal Medicine at Prince George's Hospital Center in Cheverly, Md.

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What is simulation?

Simulation is a technique for replacing or amplifying real situations with guided experience for immersive, interactive education, training, assessment, and research.^{2,3}

Simulation can be used in a variety of settings, from an actual patient-care room to the OR, allowing the user to develop in situ skills or perform drills in the management of routine and emergent events. Simulation can also be used to recreate clinical environments via computer, video, or Internet-based platforms in a simulation center, dedicated simulation laboratory, or multipurpose room for training individuals, small groups, and multidisciplinary teams.

What is a simulator?

It is an object, device, situation, or environment by which or in which a task or sequence of tasks can be realistically and dynamically presented.^{2,4} A simulator is but one of many technologies applicable to or required for simulation. However, as Cooper and Taqueti noted in their commentary on the subject, the term is often used and generically applied to all technologies used to imitate tasks.² These “technologies” may range from simple “what if” discussions and role playing to virtual reality and haptic environments.

A few examples:

- **A part-task trainer** depicts an area, section, or region of the human body for learning or practicing basic task-related skills, surgical gestures, or procedures
- **A procedural simulator** allows for comprehensive or complex skills training. Part-task trainers used in this way have been described as procedural simulators. The distinction between part-task trainers and procedural simulators is likely to diminish as technology evolves
- **A patient mannequin.** This simulator, as well as part-task trainers and procedural simulators, can be used with standardized patients (real humans) and other simulators to facilitate physical and

psychological realism across a spectrum of learners

- **Computer-screen systems** or “screen-based simulators.” These systems can recreate an area, section, or region of the human body or a clinical setting to facilitate practice of procedural skills, patient care, clinical decision-making, teamwork, and behavioral skills
- **A virtual reality (VR) or haptic simulator** augments the simulation experience with visual, auditory, or tactile feedback, and tracks the user’s performance over time. A total immersive, VR training environment that replicates all that humans are able to perceive in a real clinical environment is not yet commercially available.

In gynecology, part-task trainers and procedural simulators include:

- devices for practicing knot-tying and suture placement
- anatomic models of the female breast for detecting pathology
- pelvic models such as the ZOE Gynecologic Simulator (Gaumard Scientific) for placement and positioning of contraceptive devices or practicing vaginal exams and procedures (**FIGURE**, page 38) laparoscopic box and VR trainers for practicing a variety of intra-abdominal surgical skills and procedures
- hysteroscopy trainers
- Pelvic ExamSim (METI), an instructor-driven simulator that feeds back specific information for objective assessment of the trainee’s clinical skills during examination of the female pelvis
- a high-fidelity human patient mannequin for simulating complex, multidisciplinary gynecologic surgery scenarios. A female model was recently devised and is undergoing refinement.⁵

What can simulation offer the gynecologist?

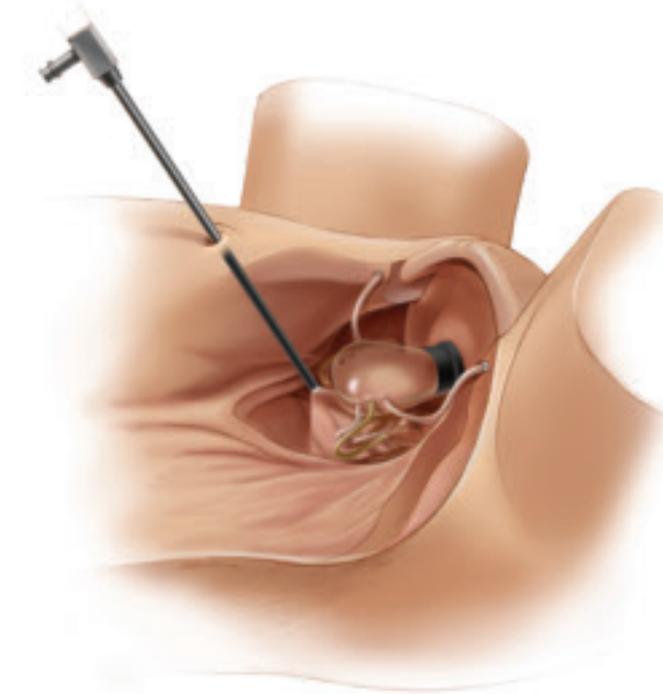
It speeds development of laparoscopic skills

The honing of laparoscopic skills by performing simulated tasks on a video trainer

**FAST
TRACK**

A total immersive, virtual reality training environment that replicates all that humans are able to perceive in a real clinical environment is not yet commercially available

Gain skills with a gynecologic simulator



The skills necessary to perform laparoscopic occlusion of the fallopian tubes can be practiced on a simulator, such as the ZOE Gynecologic Simulator, which also facilitates practice in pelvic examination, cervical and uterine assessment, IUD insertion and removal, hysteroscopy, and other skills.

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improves operative ability. That was the finding of Scott and colleagues in a study involving 27 postgraduate-year (PGY) 2 and PGY 3 residents, who were randomized to formal, simulated training in laparoscopic skills or to no training.⁶ Intraoperative global-assessment scores during laparoscopic cholecystectomy were obtained for all residents before and after the intervention, and both groups completed a laparoscopic video skills training test before and after the intervention group completed formal training. Complete data were obtained for 22 of the 27 residents—13 in the control group and 9 in the training group.

Surgical residents who completed simulation training improved significantly in overall global-assessment performance scores, compared with those in the control group ($P=.007$). They also exhibited significantly improved laparoscopic skills specific

to five tasks tested over the study period (the P value ranged from .015 to .001, depending on the task).⁶

VR simulation may be valuable in the early part of the learning curve for surgical management of ectopic pregnancy—specifically, laparoscopic salpingectomy. Aggarwal and colleagues grouped 30 surgeons by level of experience and had them perform 10 repetitions of an ectopic pregnancy module using a VR simulator.⁷ All groups improved their times, total blood loss, and instrument navigation by the second repetition. Experienced gynecologists reached a plateau across all measures by the second repetition, the intermediate group by the seventh repetition, and the novice group by the ninth repetition.⁷

In a separate study, Aggarwal and colleagues found that every hour of simulator-based training reduced the time required to achieve proficiency in laparoscopic cholecystectomy in a porcine model by 2.3 hours.⁸

Simulation can assess a surgeon's level of expertise

Fichera and associates evaluated surgeons at different levels of expertise, ranging from PGY 1 residents to full-time faculty, from the surgery and ObGyn departments at two institutions.⁹ They observed 40 subjects using the LTS 2000 (RealSim), a laparoscopic box trainer, as they completed a series of six tasks. The subjects were evenly divided between specialties and years of experience and were scored for speed and precision.

Scores did not differ between institutions, but there was a progressive, linear increase in coordination, suturing, and total scores by experience ($P < .05$). When five PGY 3 residents were retested after completing an advanced laparoscopy clinical rotation, their coordination, suturing, and total scores doubled, though the small sample size prevented statistical significance. Investigators concluded that the box trainer is a reasonable alternative to VR in this context.

Two other studies also found that simulation helped investigators distinguish experienced from inexperienced surgeons.^{10,11}

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In the first study, Gallagher and colleagues assessed the skills of 100 medical students and compared them with earlier results from a group that comprised:

- 12 experienced laparoscopic surgeons
- 12 inexperienced laparoscopic surgeons
- 12 undergraduate students who had no medical experience.

The medical students underwent supervised tests on the VR laparoscopic simulator, with six laparoscopic skills assessed on three separate occasions. Time, errors, economy of using the left and right hands, and the economy of diathermy were evaluated. After VR simulation training, the medical students' performance approached that of experienced surgeons. Testing also differentiated medical students who achieved higher scores across three repetitions of testing from those who didn't.¹⁰

In the second study, Grantcharov and associates divided 41 general surgeons into three groups, according to the number of laparoscopic cholecystectomy procedures they had performed:

- masters – more than 100
- intermediates – 15 to 80
- beginners – fewer than 10.¹¹

All surgeons were tested 10 consecutive times over one month using a VR laparoscopic simulator, with assessment of time for task completion, number of errors, and economy of hand movements. Not surprisingly, the masters group performed best, followed by intermediates and beginners ($P < .05$). However, the masters group did not significantly improve its scores over time, whereas both the intermediate and beginner groups did in all areas ($P < .05$).

VR training facilitates transfer of skills to the OR

Seymour and colleagues conducted a randomized, double-blind, controlled trial evaluating VR simulator-based training among 16 surgical residents from PGY 1 to PGY 4.¹² After assessment of baseline skills, the residents were randomized to simulator training ($n=8$) or no simulator training ($n=8$). Both groups received standard training and

performed laparoscopic cholecystectomy during the study period. Videotapes of gallbladder dissection were reviewed.

VR training involved performing a series of tasks until criteria for advanced skill were met. Each resident undergoing VR training was assessed in eight predefined categories (errors) for each procedure minute.¹²

There was no difference between groups in baseline skills. By the end of the study, all residents who underwent VR training met advanced skill criteria, and their technical skill during gallbladder dissection improved to a greater degree than that of the control group. In addition, the length of time required for dissection of the gallbladder was 29% shorter in the group that underwent VR training, though this difference was not statistically significant. The mean number of errors during dissection was roughly six times higher in the control group (7.38 errors per case versus 1.19 errors per case; $P = .008$).¹²

In a randomized study by Grantcharov and colleagues, 20 surgeons who had limited experience with laparoscopic cholecystectomy were randomized to VR simulation training or no VR training.¹³ Pre- and post-intervention assessment of their laparoscopic cholecystectomy skills was performed by expert surgeons blinded to the subjects' training status. Videotape recordings of gallbladder dissection were also analyzed.

Complete data were available for 16 of the 20 eligible participants. Investigators found no difference between groups in baseline intraoperative skills. Inexperienced surgeons who completed VR simulation training significantly improved laparoscopic cholecystectomy skills, achieving shorter time ($P < .021$), fewer errors ($P = .003$), and greater economy of hand motions ($P = .003$), compared with the control group.¹³

Simulation can improve the skill and success of the team

Simulation can be used to transmit, assess, and refine the skills necessary for optimal teamwork in the management of both routine and crisis events. For example,



The time required for gallbladder dissection in laparoscopic cholecystectomy was 29% shorter among residents who underwent virtual reality training

Aggarwal and colleagues developed a simulated OR, where they created scenarios to address performance, communication, and decision-making among members of a multidisciplinary surgical team.¹⁴ They viewed the simulated OR as a bridge between the learning of skills and eventual competence in a real OR. The simulated OR also served as a way of assessing individuals and teams and exploring external factors that influence them. The ultimate goal of such training: to reduce errors and adverse events in the care of surgical patients.

In the United Kingdom, Moorthy and associates divided 27 surgical trainees into three groups, based on their experience performing a high-level vascular procedure:

- senior – more than 50 cases
- middle – 20 to 50 cases
- junior – less than 20 cases.¹⁵

Participants performed the vascular procedure in a simulated OR, and the simulated patient developed hypoxia during the procedure. Investigators then evaluated the participants' procedure-specific skills, essential OR skills, and teamwork.¹⁵

In the assessment of procedure-specific skills, the trainees were differentiated by experience ($P=.002$), but in the assessment of essential OR skills and teamwork, they were not ($P=.70$). All participants scored poorly in communication and vigilance.¹⁵

In a separate study, Moorthy and colleagues divided 20 surgeons into two groups, based on their experience performing an advanced vascular procedure:

- more than 50 procedures
- 20 to 50 procedures.¹⁶

Trainees performed the vascular procedure in a simulated OR, and a simulated bleeding crisis evolved. The ability of the trainees to control the bleeding was assessed using a global rating scale originally developed for the aviation industry, focusing on:

- communication within the team
- time needed to complete specific tasks
- a surrogate outcome measure of total blood loss (the amount of blood captured in the canister and weight of blood-soaked sponges were also measured)

- the trainees' perception of the simulated experience
- differences between junior and senior trainees in managing the crisis.¹⁶

The simulated scenario was well received and deemed to be realistic by participants. Senior-level trainees recognized the bleeding crisis sooner ($P=.01$) and intervened more quickly ($P=.001$), whereas junior trainees were more likely to blindly apply instruments to stop the bleeding. As a result, they experienced greater blood loss and were less likely to realize their limitations and call for help. Assessment helped identify variations in response and determine which trainees needed further assistance.¹⁶

As for teamwork, scores did not differ significantly between groups, but did vary widely *within* each group. Investigators postulated that the lack of focus on team skills in surgical training was the likely reason for the variation and acknowledged a need for additional research to assess the structure and content of their teamwork rating scale.¹⁶

Powers and associates conducted a similar simulation involving five experienced surgeons and five novices, who were compared using validated rating scales. Among the variables analyzed were the time to diagnose bleeding, time to inform the team of the need to convert to laparotomy, and the actual time it took to convert. Eighty-five percent of participants, who included 10 experienced OR nurses, deemed the simulation to be realistic.¹⁷

Not surprisingly, the expert surgeons had technical and nontechnical skills superior to those of the novices ($P<.05$). Investigators concluded that the simulation was successful and realistic, with the potential to train and evaluate surgeons in specific procedures, tasks, and teamwork skills.¹⁷

Simulation can inform the credentialing process

Simulation is being incorporated into specialty and subspecialty board exams in the United States and abroad to assess task-oriented and behavior-based competencies for professional certification in general surgery



Simulation is being incorporated into specialty and subspecialty board exams in the United States and abroad in general surgery, disaster medicine, and anesthesiology

and disaster medicine in the United States, and anesthesiology in Israel. It also is being used in the certification of surgeons reentering practice. In addition, professional organizations are incorporating simulation in the credentialing and recertification processes.

As of 2008, the Accreditation Council for Graduate Medical Education Residency Review Committee for Surgery requires all surgical residency programs to ensure that residents have access to surgical-skills training labs.¹⁸ As of July 1, 2009, successful

Are some simulators better than others?

To explore this question, Munz and colleagues assessed the basic laparoscopy skills of 24 medical students, who were then randomized to the box trainer, VR trainer, or a control group.²⁴ After simulation training, both intervention groups improved their scores relative to the control group ($P < .05$), and there was no statistically significant difference in the scores between the box trainer and VR trainer groups.

Another study found that third-year medical students in ObGyn and general surgery rotations achieved proficiency in task performance and timely task completion whether they trained with laparoscopic VR or non-VR simulators.²⁵ However, those who trained with a VR simulator achieved proficiency sooner, though this finding was not statistically significant. Investigators were not able to recommend one simulator over another, since training on VR and non-VR systems facilitated the acquisition of surgical skills.

Among the models deemed reliable for training in a separate study were bench, video, and VR trainers because they produced quantifiable improvement in skills and transferred to surgical procedures in live patients.²⁶

Chou and Handa strongly support VR-based systems as well as physical simulators because software can objectively and digitally capture the performance of tasks, completion times, efficiency of surgical maneuvers, and use of instruments.²⁷

Standardization of tasks and scoring boosts utility of the box trainer

Both the box trainer and VR laparoscopic systems are used to assess surgical skills and competency. One drawback of the box trainer is the need for experienced staff to observe the trainee's performance and provide feedback. Gor expressed concern about this need, arguing that the observation and feedback could be subject to bias.²⁸

The McGill Inanimate System for Training and Evaluation of Laparoscopic Skills (MISTELS)—a box trainer—was designed to overcome observer bias by standardizing the performance of tasks and scoring.²⁹ MISTELS

has since become the simulator used by SAGES to teach FLS, a combination Web- and simulation-based education program that entails performing a series of prescribed, nonprocedure-specific tasks on the MISTELS (now known as the FLS box trainer), on which each trainee is also objectively scored.³⁰ Any general surgery resident who graduates after July 1, 2009, must document that he or she has completed the FLS program.¹⁹

FLS curriculum may benefit gynecologic surgeons, too

Because the FLS curriculum is not procedure-specific, it should be of value for gynecologists. Zheng and colleagues evaluated its validity in assessing the competency of gynecologists who perform laparoscopy.³¹ They recruited 42 gynecologists from two US hospitals, including 10 junior and 13 senior residents, 7 fellows, and 11 attending physicians. Although FLS manual test scores were differentiated by level of experience ($P = .009$) and also differed between attending physicians and junior residents ($P = .001$), cognitive test scores were low overall, and advanced gynecologists (mean score = 46.5 ± 7.1) did not score well relative to junior physicians (mean score = 48.1 ± 5.6). Pre- and post-FLS survey results revealed a high correlation between self-reported confidence and FLS manual skills ($r = 0.54$; $P = .001$), but poor correlation between self-reported confidence and FLS cognitive test scores ($r = 0.16$; $P = .352$).³¹

Based on these findings, Zheng and colleagues recommend revision of the cognitive portion of the FLS test and inclusion of more nonprocedure-specific questions to ensure that it will be a relevant assessment tool for gynecologists.³¹ Until such revisions are made, the idea of requiring gynecologists or trainees to document FLS certification as part of credentialing and assigning privileges remains controversial. However, the current version of the FLS program offers laparoscopic surgeons and trainees a valid, systematic way to assess and practice basic surgical skills in a standardized fashion before operating on live patients.

completion of the fundamentals of laparoscopic surgery (FLS), a program developed by the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES), is required for general surgery certification by the American Board of Surgery.¹⁹

In 2006, Julian and Rogers described the training needed for gynecologic surgeons to maintain integrity of surgical practice, ensure competency of surgeons, from novice to expert, and ensure patient safety.²⁰ They

proposed 1) an evidence-based educational approach to standardize surgical education and 2) the metrics used to assess outcomes. They strongly recommended requiring trainees to practice basic surgical skills in a standardized, systematic fashion before operating on live patients.²⁰

What does the future hold?

Continued growth in the use of simulation in gynecology is expected in the foreseeable future. In 2004, Gaba optimistically predicted seamless integration of simulation within the fabric of health care.³ A number of variables are driving this integration:

- the 80-hour limit on residents' weekly workload
- reduction in the medical workforce
- the increasing rate of physician reentry into the medical workforce
- other issues related to medical liability.

Also in 2004, the American Residency Coordinators in Obstetrics and Gynecology (an ACOG body) observed that an introduction to simulation and an assessment of surgical skills were among the items most residency training programs include in the orientation of residents.²¹

The Council on Medical Education recently recommended to the American Medical Association that the effectiveness of simulation in teaching and assessment be evaluated, as well as its suitability for inter-professional education, clinical team-building, and licensure and certification.²²

Among the challenges to seamless integration of simulation into health care are cost, quality of the simulation models, the time and space needed for simulation-based education, and the need for specialty-specific curricula that have been standardized and validated for competency assessment and professional certification.

Further research is required to advance our understanding of simulation, specifically, the ideal curricula for novices and experts, and how best to embed simulation into the lifelong learning and self-education of ObGyns.

The first simulator? An extirpated uterus

Hysteroscopy was invented in the late 1880s, but almost 100 years passed before Trygve Kleppinger of Pennsylvania patented the first hysteroscopy training device: an extirpated uterus mounted on a platform.^{32,33}

Gynecologists Telinde and Palmer first adapted laparoscopic visualization of the abdominal organs for use in gynecologic surgery in the 1930s and 1940s, but it wasn't until 1985 that Semm created the first laparoscopic training device, complete with a plexiglass cover to provide the operator with a direct view of technique.^{34,35} (Video screens now provide such capability.)

In 1993, Satava proposed that virtual reality (VR) technology and laparoscopic training devices be integrated.³⁶ Since then, that proposal has been actualized in a variety of minimally invasive surgical simulators, including hysteroscopic models. They range from box trainers, such as the FLS Laparoscopic Trainer Box (Society of American Gastrointestinal and Endoscopic Surgeons), to simulators outfitted with virtual or haptic components.

Robotic telepresence technology was developed by the military during the 1990s to provide surgical assistance for procedures on victims in remote areas.³⁷ Since 2000, robotic-assisted surgical systems have been used for a variety of cardiac, neurosurgical, orthopedic, general surgery, and urologic surgery procedures.

The robotic console, da Vinci Surgical System (Intuitive Surgical), was approved by the Food and Drug Administration in 2005 for use in gynecologic laparoscopy procedures, including hysterectomy and myomectomy, correction of vaginal prolapse, and extirpation of gynecologic cancers.³⁸

Although the surgical robotic platform lends itself well to simulation-based skills training, the cost of using the robot exclusively for training would be prohibitive, as the price per unit exceeds \$1 million. There is one surgical robot simulator, however: the SEP-robot simulator (SimSurgery AS), a VR-based device. It has been available in the United States since 2007 as SurgicalSIM RSS (METI).^{39,40}

Another robot surgical simulator, the dv-Trainer (Mimic Technologies) is undergoing beta-testing and validation studies.⁴¹

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As Goff reminds us, our participation in such endeavors is critical “if we hope to remain a self-regulated profession.”²³ Now is the time for gynecologists to participate in shaping the future of our profession. 

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