MS NO: ONG-20-838

Current Commentary

Home Surgical Skill Training Resources for Obstetrics and Gynecology Trainees During a Pandemic

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The coronavirus disease 2019 (COVID-19) pandemic has created a unique educational circumstance in which medical students, residents, and fellows find themselves with a gap in their surgical training. We reviewed the literature, and nine categories of resources were identified that may benefit trainees in preventing skill decay: laparoscopic box trainers, virtual reality trainers, homemade simulation models, video games, online surgical simulations, webinars, surgical videos, smartphone applications, and hobbies including mental imagery. We report data regarding effectiveness, limitations, skills incorporated, cost, accessibility, and feasibility. Although the cost and accessibility of these resources vary, they all may be considered in the design of remote surgical training curricula during this unprecedented time of the COVID-19 pandemic.

(Obstet Gynecol 2020;136:1–9)
DOI: 10.1097/AOG.0000000000003931

The coronavirus disease 2019 (COVID-19) pandemic has led hospitals worldwide to cancel elective surgical procedures. Residency programs have moved to skeleton call teams, and medical schools have gone virtual. Although these protocols have helped decrease infection exposure, many trainees find themselves at home with an undefined gap in their hands-on training. There are no guidelines for remote surgical training, nor are there many recent reviews pertaining to gynecology simulation. Residents may encounter *surgical-skill decay*, defined as loss of acquired skills after a period of nonuse, which has been found to increase as the nonpractice interval lengthens.[1,2] In the military, cognitive decay was seen at 6 months and motor decay was seen at 10 months.[2] Fortunately, simulations have been shown to be effective in preventing decay and teaching new technical skills to novice learners who have delayed the initiation of their training.[3–8] Three core skills are vital when designing an effective laparoscopic-skills program: psychomotor skills, visual–spatial skills, and cognitive skills.[2] We believe these same core skills can be applied and generalized to basic surgical training such as knot tying, suturing, and surgical dissection. The purpose of this review is to explore available resources for remote surgical training with attention to the three core skills addressed, cost, and feasibility.

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Each author has confirmed compliance with the journal's requirements for authorship.

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Financial Disclosure
The authors did not report any potential conflicts of interest.

ISSN: 0029-7844/20

METHODS

Two authors (S.H. and T.P.) independently performed comprehensive searches of the medical literature in PubMed using the same search terms. The results from both searches yielded abstracts and articles that were compiled and reviewed. Keyword search terms included "at-home," "homemade," "remote," "surgical skill training," "laparoscopic skill training," "surgical simulation," and "laparoscopic simulation." A review of major surgical and gynecology societies' websites was performed to search for applicable simulation models, instructions, modules, and surgical videos. These organizations included the American College of Obstetricians and Gynecologists, the American College of Surgeons, the Fundamentals of Laparoscopic Surgery program, the International Academy of Pelvic Surgery, the AAGL, the International Urogynecological Association, and the American Urogynecologic Society. The Apple Inc. application store was used to search for surgical training applications using the search terms "surgical skills" and "surgical simulation." Finally, a Google search was conducted to find other web-based surgical simulation sites. Resources were categorized by type of simulation, benefits, limitations, cost, and which of the three core skills were incorporated: psychomotor, cognitive, visual–spatial.

RESULTS AND DISCUSSION

Laparoscopic Box Trainers

Initially designed for hospital simulation centers, laparoscopic skill trainers have been made portable for trainees to practice, master repetition, and develop muscle memory at home. Laparoscopic box trainers and instruments can be purchased from a variety of manufacturers (Table 1). These simulators require the use of both psychomotor and visual–spatial skills essential for successful laparoscopic surgeries. When surveyed, residents felt that box trainers were effective and useful to have at home.[9,10] Furthermore, residents randomized to take-home trainers were more likely to practice their skills and had improved suture-retention scores compared with those randomized to institutional trainers.[11] The main limitation of a purchased box trainer is cost, making these less feasible for individual training during a pandemic, especially because sharing of trainers is limited by stay-at-home orders (Table 1). Homemade trainers can be made out of cardboard, wood, or plastic boxes, with a web camera or tablet, depending on what supplies are accessible[12,13] (Fig. 1). When residents were randomized to a homemade trainer compared with a manufactured trainer, there was no significant difference in time to completion of the practiced Fundamentals of Laparoscopic Surgery tasks.[14] Residents using a home trainer had no difference in surgical skill scores compared with those who completed a course of didactics and supervised laparoscopic skill training.[15] Furthermore, remote video coaching sessions with an expert surgeon have been found to improve laparoscopic skills in residents.[16–18] Using a smartphone or tablet with their homemade trainer allows residents to record their efforts and share them remotely with faculty. To encourage use, programs should include goal setting for each task and a log of training time.[19] Unlike manufactured trainers that include laparoscopic instruments, homemade trainers require programs to purchase instruments online ($70–$170) or borrow them from the hospital and distribute them by mail or during call shifts. These trainers can be used to help residents prepare for their Fundamentals of Laparoscopic Surgery certification to prevent further delay in examination from lack of preparation. Detailed task instructions and required instruments can be found on both the American College of Obstetricians and Gynecologists' Curriculum for Resident Education in Surgical Technique and the Fundamentals of Laparoscopic Surgery website.[20,21]

Virtual Reality Laparoscopic Trainers

The addition of virtual simulation adds a degree of cognitive skill to the mix of psychomotor and visual–spatial skills used in the generic trainers described above. Students learn from mistakes as they work through different procedures. Virtual reality trainers have been shown to decrease skill-completion time, with better recall of procedural steps compared with watching surgical videos.[22,23] A systematic review of 14 randomized trials found that virtual reality training led to improved peg transfer time and improved performance of minimally invasive surgery in a descriptive analysis.[24] Nonetheless, the review found no difference in time to completion of laparoscopic tasks on virtual reality trainers compared with standard trainers.[24] Some virtual reality trainers lack haptic feedback, a feature that reduces the learning curve and improves realism.[25] To ameliorate this limitation, augmented reality simulators have been developed, incorporating the use of physical objects to provide haptic feedback.[26] There are several manufacturers for these systems, and they range in price from $2,000 to more than $100,000[8] (Table 1). Bulky robotic simulators also exist and cost from $80,000 to more than $137,000, limiting their use in a remote curriculum.[27] Given these findings and the substantial cost difference, the standard box trainer is sufficient to enhance remote surgical training; however, when a virtual reality trainer is available, programs should allow its use because it provides the cognitive and coaching feedback not otherwise included in a box trainer.[28]

Homemade, Low-Cost Simulation Models

Several organizations offer instructions on how to create models for surgical simulation with a comprehensive list of materials, costs, learning objectives, modules, and quizzes (Table 2). In contrast to the specialized materials needed for laparoscopic trainers, these models use common household materials, such as kitchen sponges to simulate tissue dissection, plastic pipes and tights to simulate anterior colporrhaphy, or modeling clay and pantyhose to simulate a vaginal hysterectomy.[29–31] Other examples can be found on PubMed, including a modified beef tongue model for fourth-degree laceration repair.[32] These models allow trainees to improve their psychomotor and

Table 1. Summary of Remote Surgical Training Resources

Resource	Examples	Skills Practiced	Benefits	Limitations	Cost
Box trainer	Ethicon GT Simulators 3B Scientific Laparo Medical Simulators Homemade trainers	Psychomotor Visual–spatial	Practice FLS examination skills Portable Use of laparoscopic instruments Haptic feedback Found effective by residents[8,9]	Cost No procedure simulation Limited feedback	Manufactured: $250–$1,000 Homemade: $70–$300
Virtual reality trainer	LAP-X (MEDICAL-X) CAE LapVR LAPSIM LAP MENTOR VirtaMed	Psychomotor Visual–spatial Cognitive	Practice FLS examination skills Reviews procedure steps Use of laparoscopic instruments Anatomy reviewed	As effective as a box trainer[21,23] Varied haptic feedback	Prices quotes available (~$2,000–$100,000 or more)
Homemade low-cost simulators	ACOG[A]* AUGS[B] Other low-cost simulation models	Psychomotor Cognitive	Includes quizzes and modules Reviews procedure steps Haptic feedback Low cost Improved confidence, satisfaction, and skills[28–33]	Construction time Purchase of supplies Access maybe limited to members Not studied in unfacilitated settings Difficult to share models Advanced models require 2 participants	Model: $7–$100 Tools: $10–$40
Video games	Nintendo Wii (Marble Mania or Wii Play) Xbox (Call of Duty, Super Monkey Ball, Star Wars Racer Revenge)	Visual–spatial Psychomotor	Accessible	No review of medical procedures No haptic feedback No well-studied regimens Limited evidence of effectiveness[34,42–44]	$100–$400
Online simulation modules	Incision Academy[C] SimPraxis simulation[D] FLS training modules Robotic Training Network[E] NEJM[F] and Lancet[G] interactive medical cases Human Diagnosis Project[H]	Cognitive	Includes videos, anatomic models, quizzes Interactivity improves learning outcomes[58] Accessible	Not hands-on No use of surgical instruments Effectiveness not well studied	~$250/year; free during COVID-19 crisis
Online modules and webinars	AUGS[I] ACOG[A] IUGA[J] AAGL (SurgeryU)[K] Learn Gyn Surgery[L]	Cognitive	Published by medical societies Accessible Effective[51,52]	Not hands-on No use of surgical instruments Less interactive	Membership, $0–100/y for residents
Surgical videos	Video libraries (AAGL[K], IAPS[M], SGS[N], IUGA[J], ACS[O]) AUGS webinars[I] Green Journal channel[P] and gallery[Q]	Cognitive	Reviews procedure steps Short Includes uncommon surgeries	Not hands-on No use of surgical equipment Less interactive Mixed quality Mixed evidence in terms of effectiveness[54–58]	Membership, $0–100/y for trainees; possible COVID-19 discount

(*continued*)

Table 1. Summary of Remote Surgical Training Resources (*continued*)

Resource	Examples	Skills Practiced	Benefits	Limitations	Cost
Smartphone applications	Touch Surgery[R] Doctor Training[S]	Cognitive Visual–spatial	Interactive Reviews procedure steps Accessible	No use of surgical equipment No haptic feedback Not regulated	Free
Hobbies and mental imagery	Musical instrument Sports Mental imagery Crafting	Visual–spatial Psychomotor	Relaxation mechanism Variety Improved dexterity[79,83] Mental imagery improves laparoscopic skills[84,85]	No use of surgical equipment No review of procedures Limited evidence supporting use	Varies

FLS, Fundamentals of Laparoscopic Surgery; ACOG, American College of Obstetricians and Gynecologists; AUGS, American Urogynecologic Society; NEJM, New England Journal of Medicine; COVID-19, coronavirus disease 2019; IUGA, International Urogynecological Association; IAPS, International Academy of Pelvic Surgery; SGS, Society of Gynecologic Surgeons; ACS, American College of Surgeons.
* Superscript letters correspond to web links that are included in Appendix 1, available online at http://links.lww.com/AOG/B887.

visual–spatial skills while also reinforcing knowledge of gynecologic procedures. Most simulation supplies are relatively low-cost ($7–$100 for the model and $10–$40 for surgical tools or an anatomy dissecting kit) and range in difficulty of construction. Not all publications cite validity of their model or an improvement in performance. Some publications show improved trainee confidence and satisfaction after model use,[33–35] whereas others show significant improvement in a surgical skill.[36,37] One limitation is that these models are usually designed for performance in a structured laboratory led by faculty, with supplemental didactic sessions.[38] No studies instructed trainees to perform these models without facilitators. Although remote video coaching is available, more advanced models (such as hysterectomy) require two participants.[31,34] Under stay-at-home orders, trainees may create their own models or share using a cleaning protocol. In summary, individuals can build low-cost surgical models to practice all three core skills at home.

Video Game Training

Video game play has been associated with improved psychomotor skills, eye–hand coordination, reaction time, and spatial visualization.[39,40] Overall, there is mixed evidence supporting a correlation between prior video game play and baseline laparoscopic surgical skills.[41–46] The most widely studied video game platforms are the Nintendo Wii and Xbox (Table 1). Based on a few small studies, some video games were found to improve nondominant-hand performance,

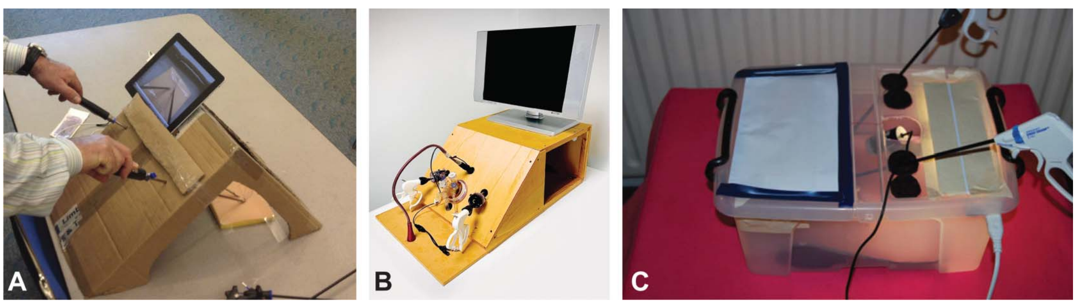

Fig. 1. Three homemade laparoscopic box trainers. **A**. Materials: cardboard and tablet; cost: minimal (excluding tablet); time to assemble: not recorded. **B**. Materials: wood, computer monitor, and bullet camera; cost: $80; time to assemble: not recorded. **C**. Materials: plastic box, computer monitor, and web camera; cost: $50; time to assemble: 3 hours. **A** Reprinted from J Surg Educ 2013;70:161–3 with permission from Elsevier. **B** Reprinted from Int J Environ Res Public Health. 2020;171:323 under the terms and conditions of the Creative Commons Attribution (CC BY) license (http://creativecommons.org/licenses/by/4.0/). **C** Reprinted from Clin Teach 2011;8:118–21 with permission from John Wiley and Sons.
Hoopes. Remote Surgical Skill Training Resources. Obstet Gynecol 2020.

Table 2. Examples of Published Homemade Surgical Simulation Models, Including Materials, Cost, and Assembly Time

Procedure Simulation	Sponsoring Organization	Materials	Cost	Assembly Time
Hysterectomy (vaginal, laparoscopic, and abdominal)*	ACOG	Plastic flower pot, screws, washers, plywood, garden wires, fabric, spray adhesive glue, thick foam, pool noodle, foam balls, yarn, elastic band, Press'n Seal wrap, cotton fiber, vise-grip tools	$20	1 h
Anterior vaginal wall dissection*	ACOG	Plastic flower pot, heavy-duty scrub sponge, corkboard or plastic platform, plastic spring clips	NI	NI
Vaginal hysterectomy[†‡]	AUGS, Boston University	Resin pelvis, zip ties, clay material, ribbon, panty hose, cotton batting, rubber band, gauze, clear plastic bag, tape	$42	NI
Anterior colporrhaphy[§]	AUGS, Hartford Hospital	Plastic pipe connector, wood base, tights, batting sheet, adhesive hook-and-loop fastener, thumb screws, perforated steel duct strap	$46	NI
4th-degree laceration[‖]	*Obstetrics & Gynecology*	Beef tongue, beef tripe, chicken leg segments	$7	1 h

ACOG, American College of Obstetricians and Gynecologists; NI, not included; AUGS, American Urogynecologic Society.

* American College of Obstetricians and Gynecologists. Simulation: total abdominal hysterectomy. Available at: https://www.acog.org/education-and-events/simulations/scog010/simulation. Retrieved April 7, 2020.

† American Urogynecologic Society. A low-cost, high-fidelity simulation model for vaginal hysterectomy. Available at: https://augs.digitellinc.com/augs/sessions/4867/view. Retrieved April 7, 2020.

‡ Anand M, Duffy CP, Vragovic O, Abbasi W, Bell SL. Surgical anatomy of vaginal hysterectomy-impact of a resident-constructed simulation model. Female Pelvic Med Reconstr Surg 2018;24:176–82.

§ American Urogynecologic Society. Video2969—anterior colporrhaphy: simulation training model. Available at: https://augs.digitellinc.com/augs/sessions/6236/view. Retrieved April 7, 2020.

‖ Illston JD, Ballard AC, Ellington DR, Richter HE. Modified beef tongue model for fourth-degree laceration repair simulation. Obstet Gynecol 2017;129:491–6.

intracorporeal knot-tying performance, electrocautery skills, and basic laparoscopic skills.[47–52] Because many residents may already own gaming platforms, game practice would be easily incorporated into a remote curriculum; however, the evidence is too weak to support routine use of these systems.

Online Surgical Simulation Modules

The interactivity, repetition, and feedback gained by trainees using internet-based learning has been associated with improved learning outcomes and might be better suited for Millennial-style learning.[53–55] Online surgical simulations walk users through a procedure, followed by a reading, anatomic review, or quiz. These are similar to virtual reality trainers but without the use of surgical instruments. The Sim Praxis Laparoscopic Hysterectomy Software was found to improve post-training test scores compared with residents receiving standard training.[56] Incision Academy provides access to surgical videos, step-by-step instructions, three-dimensional anatomy models, and quizzes. Some sites have granted free access during the COVID-19 pandemic. Unfortunately, there is limited evidence to support or refute the use of these resources.

Modules and Webinars

Physicians and trainees worldwide have access to webinars and modules from experts' broadcasts or those published by major scientific societies, covering new surgical advances and current surgical techniques. Many societies offer access to these lectures with membership or for a small fee (Table 1). E-learning tutorials and videos have been found to improve surgical knowledge but are limited owing to inconsistent use of control groups.[57,58] With a wide variety of subjects and flexibility in scheduling, faculty can choose accessible topics best suited for the learner. Modules with self-assessments have been shown to have improved learning outcomes.[59] Online orientation modules to Fundamentals of Laparoscopic Surgery tasks and robotic surgery are available if not already incorporated into the curriculum.[60–62] Webinars can be watched and discussed with groups of trainees and supervisors using video chat. Future studies are needed to determine how e-learning can be used to reinforce technical skills, but, for the time being, it serves as a sufficient substitute to trainee didactics.

Surgical Videos

Surgical videos are commonly used in the demonstration of anatomy and technical skill, but their effectiveness in improving surgical performance is controversial.[63–68] The most popular video search engine for surgical trainees is YouTube, whereas specialists tend to rely on videos from surgical societies.[64,69] Caution should be exhibited when choosing videos, because there is no current peer-review process for publishing medical videos online, with many top-ranked videos showing suboptimal techniques.[70,71] To combat this issue, laparoscopic surgery video educational guidelines were developed, describing how to effectively produce videos.[72] Additionally, trainees should be directed toward society videos, such as the Green Journal's YouTube channel and online gallery, AAGL's SurgeryU, and the International Academy of Pelvic Surgery (Table 1), to ensure quality content with step-by-step instructions and commentary. Many of these libraries have granted free access to trainees during the COVID-19 pandemic.

Smartphone Applications

Several studies have demonstrated that smartphone simulation applications improve surgical skills through teaching cognitive reasoning and technical skills.[73–76] Touch Surgery is a free smartphone application that simulates key steps in surgical procedures such as hysterectomy, episiotomy, and cesarean delivery. Although this application does not provide haptic feedback, it provides immediate instruction after steps are chosen by the user. Similar to online surgical videos, the content produced by the medical applications industry is not regulated by peer review.[77] There are more than 1,000 "surgery" applications available for download, but only 12% are linked to an academic institution or society.[74,78] Although there is little research to support the use of smartphone applications in regular surgical curricula, they are easily accessible for trainees, with the potential to produce future evidence-based applications.

Hobbies and Mental Imagery

Recreational activities involving manual dexterity that may improve fine motor surgical skills, such as musical instrument playing, are mostly anecdotal in their success.[41,79] Mental imagery, a mental-training technique implemented at the University of New Mexico, was postulated to slow surgical-skill decay, improve trainees' performance, and lessen their anxiety when performed before the procedure.[80,81] Interestingly, when comparing physical practice followed by either additional physical practice or mental imagery, mental imagery was as effective as additional physical practice when medical students were learning basic suturing skills.[82] Therefore, when physical practice with surgery is not possible, mental imagery may be a cost-effective technique to aid in skill retention.

CONCLUSIONS

The COVID-19 pandemic has left many surgical students, residents, and fellows with a gap in hands-on surgical training, leaving them prone to surgical-skill decay. Fortunately, there is a diverse array of resources that can be employed to develop remote surgical curricula for the obstetrics and gynecology trainee. Implementation will vary by program, because these resources vary in price and accessibility. However, in combination, they can be used to develop the psychomotor, visual–spatial, and cognitive skills important for surgical performance. As new curricula are developed during this unique time, it is important to share resources to enhance the accessibility of gynecologic surgical simulation. Programs should take advantage of this time to collaborate and further study the effectiveness of these platforms to determine whether these resources should be implemented when trainees return to their programs.

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PEER REVIEW HISTORY

Received April 10, 2020. Received in revised form April 17, 2020. Accepted April 22, 2020. Peer reviews and author correspondence are available at http://links.lww.com/AOG/B888.