

Virtual Surgical Training During COVID-19

Operating Room Simulation Platforms Accessible From Home

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As the impact of coronavirus disease 2019 (COVID-19) continues to permeate throughout global healthcare systems, the lives of staff physicians, medical and surgical residents, medical students, and other allied healthcare workers are in constant flux. Priorities for healthcare workers currently center around providing effective patient care, ensuring adequate personal protective equipment, ventilator supply, and hospital capacity. In an effort to increase hospital capacity to account for the surge of critically ill COVID-19 patients and to protect healthcare workers, the American College of Surgeons recommended that all hospitals, “review all scheduled elective procedures with a plan to minimize, postpone, or cancel electively scheduled operations, endoscopies, or other invasive procedures” until further notice.¹

The American College of Surgeons recommendation has undoubtedly left surgical residents and trainees in a precarious position. With a dramatic reduction in operative exposure, and in some cases, with a mandate to remain at home, how will surgical trainees maintain their surgical skill and intraoperative knowledge? Fortunately, given significant technological advancements over the past several decades, there remain a number of options for the maintenance of intraoperative knowledge beyond textbook-learning that are easily accessible from home. Computer- and phone-based technologies provide access to intraoperative video recordings, virtual reality operating room simulations, and other interactive surgical platforms. Such applications are widely available and have the potential to satisfy and supplement the learning needs of surgical trainees as defined by surgical education governing bodies.² Moreover, surgical simulation has the potential to increase objective technical proficiency in the operating room, decrease intraoperative errors, and decrease operative time.³

The aim of the present article is to provide an overview of the available computer- and phone-based platforms accessible at home for surgical trainees who currently have limited surgical exposure given the ongoing COVID-19 pandemic. Such a review may allow surgical trainees and surgical education governing bodies to initiate and create at-home surgical curricula during the COVID-19 pandemic.

COMPUTER-BASED PLATFORMS

Exponential growth of computer processing power over recent decades has fueled a parallel expansion of computer-based surgical platforms. Currently, over 20 computer-based platforms, ranging over 9 surgical specialties, are available on the internet and are accessible from home. Fifteen computer-based platforms are freely accessible, 1 platform (*Incision Academy*) is offering a 4-week free trial during the COVID-19 pandemic, and 7 platforms require paid accounts.

Two paid platforms present material pertaining to all surgical specialties. The Surgical Council on Resident Education Portal provides an online surgical curriculum with access to over 800 modules, 2,000 multiple choice questions, and 220 narrated intraoperative videos. Approximately 95% of American General Surgery residency programs subscribe.⁴ It has been demonstrated that residents with an active subscription to the Surgical Council on Resident Education Portal score higher on their American Board of Surgery Qualifying Examination.⁵ The *Journal of Medical Insight* is a peer-reviewed surgical video journal that offers annotated intraoperative videos along with supporting primary literature, organized neatly into “chapters.” Each chapter pertains to a specific step of the selected procedure, and offers an opportunity for self-assessment. Access to this platform costs \$50 per month or \$500 per year for surgical residents.

Two platforms focus solely on General Surgery and 6 have content pertaining mostly to General Surgery whereas also having additional modules focused on other surgical specialties. *Incision Academy* is a European-based online platform that presents live intraoperative video. It details the steps of a given operation, provides primary literature evidence, allows for interactive anatomy learning relevant to the operation, and has a section for self-assessment. They have released a free 4-week trial in light of the COVID-19 pandemic. *WebSurg* is an online platform that publishes multimedia General Surgery, and Gynecology, content monthly. It is produced by the Institute for Research into Cancer of the Digestive System (France) and is supported by Medtronic and Karl Storz. Over 2000 sequenced and subtitled intraoperative videos in 7 languages are currently available. This platform also offers free live webinars and conference broadcasts. Users must register a free online account for full access. *Teach Me Surgery* has a large General Surgery section and sections available for other surgical specialties. This is a free platform that organizes over 400 peer-reviewed articles, has over 1000 interactive clinical images, and allows for self-assessment. Similarly, *Surgery Squad* caters to General Surgery, Ophthalmology, and Obstetrical procedures. It is an interactive, virtual reality platform that allows the user to progress through the key steps of an operation.

Five platforms focus primarily on Otorhinolaryngology – Head & Neck Surgery. *e-lefENT* is a United Kingdom-based, interactive, and self-assessment driven online platform that is mapped to fit the Intercollegiate Surgical Curriculum Programme. It is funded by Medtronic and requires a paid subscription. *Headmirror* is an online

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surgical atlas with live, narrated intraoperative videos spanning numerous subspecialties (ie, facial plastic surgery, head and neck surgery, laryngology, otology and neurotology, rhinology and sinus surgery, pediatric otolaryngology). It is free platform maintained by the Otorhinolaryngology – Head & Neck Surgery department at The Mayo Clinic.

There are 3 ophthalmology-specific platforms available, 2 of which are free to all users. Eye Tube is an online platform that allows users to view fully narrated live intraoperative videos of ophthalmology procedures (ie, cataract, glaucoma, oculoplastics). It offers a new 3-dimensional channel for intraoperative viewing. eIntegrity is a paid platform sponsored by the National Health Services and the Royal College of Ophthalmologists.

Three orthopedic-specific computer-based platforms are available from home. Ortho Oracle is a surgical atlas that contains live, intraoperative videos for the following orthopedic subspecialties: shoulder and elbow, hand and wrist, spine, hip, knee, foot and ankle, and oncology. It is a United Kingdom-based platform that costs 7 euros per month for a full subscription. The full version allows you to take notes on their platform while watching videos and uses International Business Machines Corporation Watson to deliver relevant primary literature. AO Surgery Reference is an online repository for the management of fractures at any anatomic location. It provides free access to interactive modules that progress through key steps (with picture instructions) of preoperative, intraoperative, and postoperative fracture management. Fundamental Surgery requires access to HapticVR technology.

Two platforms have been validated in peer-review publications. Simulation General and Thoracic Surgery increased resident knowledge base in thoracic surgery procedures (pre-test: 42.5% vs post-test: 78.6%, $P < 0.0001$) and enhanced confidence when preparing for live thoracic procedures.⁶ It is a free platform affiliated with the University of Virginia that incorporates ex-vivo videos aimed at highlighting essential steps and equipment for thoracic operations (eg, Nissen Fundoplication, Repair of Acute Esophageal Perforation, Left Postero-Lateral Thoracotomy). CyberSight is a free online surgical learning platform that includes modules focused on the following topics: cataract surgery, cornea anatomy, glaucoma, pediatric ophthalmologic disease, and strabismus. These courses were developed and delivered by Ophthalmologists from around the world, including UC Davis Eye center, New England College of Optometry, and Middle East Africa Council of Ophthalmology. This platform also includes an online mentoring service that, along with the modules, have been shown to be a viable method for delivering ophthalmology expertise globally.⁷

Other available platforms include VideoUrology, Toronto Video Atlas of Surgery, Decker Med (paid subscription required), Wise-MD, and Multi-media Manual of Cardio-thoracic Surgery.

PHONE BASED PROGRAMS

In addition to web-based modalities for surgical simulation, there are educational phone-based platforms. Touch Surgery is a free-trial phone surgical simulation application that includes 12 different surgical specialties (Cardiothoracic Surgery; General Surgery; Global Surgery; Neurosurgery; Obstetrics and Gynecology; Ophthalmology; Oro-maxillofacial Surgery; Orthopedics and Trauma; Otolaryngology Head and Neck Surgery; Plastic, Reconstructive and Aesthetic

Surgery; Urology and Vascular Surgery) with over 200 procedures for surgical simulation. Furthermore, there is a self-assessment component to ensure material consolidation. Touch Surgery has been validated by 19 independent peer-reviewed publications. For example, Touch Surgery laparoscopy and intramedullary femoral nail simulations were able to significantly distinguish between expert surgeons and novices ($P < 0.001$, $P < 0.001$).^{8,9} Additionally, studies have reported that users find the surgical simulations to be realistic.^{8,9}

Level Ex developed 4 free interactive animated phone applications entitled Cardio Ex, Pulm Ex, Gastro Ex, and Airway Ex. Although Cardio Ex, Pulm Ex, and Airway Ex focus on medical/anesthesiology simulation, Gastro Ex involves colorectal surgery simulation. Gastro Ex provides users with feedback on accuracy and speed during endoscope, biopsy and cautery tasks. No peer-reviewed publications exist validating Level Ex applications.

Two free interactive, video-based surgical simulation applications from Belgium were published in 2016–2017, including My Virtual Surgery and CABG - OPCAB Surgery Training. These applications include surgical simulation from Cardiac Surgery, Vascular Surgery, Plastic Surgery, General Surgery, Obstetrics and Gynecology. All of these applications include opportunities for learner self-assessment. Other surgical simulation phone-based platforms include LapGuru, OrthoGuru, and Ensafé VATS.

CONCLUSIONS

Amidst the COVID-19 public health crisis, that has infected more than 1 million people in over 180 countries, the educational needs of surgical trainees should not be neglected. Promoting remote learning platforms such as those highlighted in the present review and integrating them into formal curriculum can expand educational opportunities beyond the walls of the hospital. Such measures may mitigate the diminished surgical skill among surgical trainees that is foreseeable in hospitals across the world.

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