Technology and Simulation to Improve Patient Safety

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KEYWORDS

• Simulation • Neurosurgery • Surgical simulator • Resident education • Neurosurgical simulator

KEY POINTS

- Neurosurgical education is increasingly looking to integrate surgical procedural based simulators as a tool for operative training and interim evaluation of skills.
- Repetitive surgical training helps the resident develop a mental rehearsal of steps. Simulation allows for that mental rehearsal to begin prior to the first operative experience. This process is particularly beneficial with infrequently encountered pathologies and procedures.
- Using simulation as an interim evaluation tool requires a validated and reliable scoring system, which poses a unique challenge in grading technical skills.

INTRODUCTION TO SIMULATION IN NEUROSURGICAL EDUCATION

Improving the quality and efficiency of surgical education, reducing technical errors in the operating suite, and ultimately improving patient safety and outcomes are common goals in all surgical specialties.[1] Modern medical education at the turn of the 20th century emphasized graduated levels of responsibility through successive years of training.[2] Modern-day simulation tools represent an effort to enhance the training experience because of the limitations of a government-mandated 80-hour work week, and have the goal of providing a well-balanced resident education in a society with a decreasing level of tolerance for medical errors.[2,3]

Early simulator use in medical training has been focused on the rehearsal of clinical scenarios, such as those required in advanced cardiac life support resuscitation training.[4] The use of simulators has expanded rapidly after positive reports correlating technical simulator proficiency with increasing measures of technical expertise in the operating suite.[5] One prospective randomized trial evaluating the use of simulation training among physicians performing laparoscopic inguinal hernia repair found significantly shorter operative times, decreased complication rates, and shorter patient hospital stays compared with those who had no prior simulation training.[6]

ORGANIZED PRESURGICAL TRAINING MODELS

In a recent survey of US neurosurgery program directors, 72% believed that simulation would improve patient outcome, and nearly half of the respondents believed that residents should achieve an agreed upon standard of simulation proficiency before receiving intraoperative training.[7] One formal implementation of simulator training could be in the form of annual objective assessments of resident operative skills. At minimum, because

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a direct effect of work-hour restriction is a decrease in operative time for residents, practice runs using a simulator would help them develop a mental "script-based rehearsal" to optimize their time spent in the operating suite.[8]

SIMULATION IN NEUROSURGERY

Simulators can be divided into physical simulators, haptic/computerized simulators, and cadaveric dissection.[3] Cadaveric simulation was the first educational tool to provide anatomic education with preserved 3-dimensional relationships. As a result, this modality has currently provided the most education. Improvements in computer and engineering technology have enabled the recent growth of computerized simulators. Eventually, computer graphics technology and passive 3-dimensional optics became affordable for implementation in neurosimulation. Lastly, techniques of 3-dimensional fabrication have allowed for realistic physical simulators to be developed at a cost affordable for training institutions.

INITIAL USE OF SIMULATION IN NEUROSURGERY RESIDENCY

Surgical "boot camps" for postgraduate first-year residents have been adopted and implemented in the past several years across a variety of surgical specialties, including cardiothoracic surgery,[9] orthopedics,[10] otorhinolaryngology,[11] and neurosurgery.[12] Surveys conducted in neurosurgery found a high level of satisfaction with and knowledge retention of the skills that were emphasized at the neurosurgical boot camp.[12] Appropriate simulators used at postgraduate year one training events have included central line placement, ventriculostomy catheter placement, and trauma craniotomy models.[12]

EXPANSION OF TRAINING ASPECTS ADDRESSED BY SIMULATORS

With the rapid expansion in available simulators, interest in incorporating these into formal training has been increasing. In the past year alone, results of several efforts have been published, with haptic feedback devices demonstrating the various aspects of microsurgical technique that can been taught outside of the operating room, ranging from tumor handling, to volumetric resection, to anatomic accuracy (**Table 1**). These technologies are ideal for techniques such as endovascular treatment of vascular pathologies,[5] craniotomies,[13,14] and endoscopic approaches.[15] In spinal surgery, new simulations are being introduced, such as the durotomy repair,[16] posterior cervical laminoforaminotomy,[17] and anterior cervical discectomy models.[18] These models have been a welcome addition to prior established simulators for percutaneous pedicle screw fixation.[19] Arguably these skills should be practiced before entry into the operating room, because textbook knowledge alone is insufficient.

CHALLENGES TO DESIGNING A FORMAL CURRICULUM USING SIMULATION IN RESIDENCY EDUCATION

The initial introduction of simulators has already been successfully incorporated into residencies and national meetings, such as the Congress of Neurological Surgeons.[20] In an attempt to fully incorporate neurosurgical simulators into resident education, an educational curriculum and evaluation tool is needed. Several challenges exist to grading surgical skills not encountered with typical testing of knowledge. The first challenge is identifying a participant's knowledge of all skills,[16] so that when repeated examination of the same participant occurs, a frame of reference is established. The second challenge is choosing the right objective structured assessment tool (OSAT) to quantitatively measure a resident's interim performance. All OSATS must be consistent across all examiners and would need to be demonstrated in future study through validation, and interobserver and intraobserver reliability studies.

PROPOSAL FOR VALIDATION OF NEUROSURGICAL SIMULATION SKILLS

One proposed pathway to a more reliable and consistent grading scheme is a video-based OSAT scoring system, rather than a traditional text-based scoring system that purely describes certain techniques on a 10-point scoring scheme.

With this technique, participants can videotape their examinations while following scripted instructions either independently or with a faculty instructor. This system would allow for formal grading by an examiner. One way to validate this method would be to have multiple examiners review and grade a submitted video, using the video-based OSAT to confirm interobserver reliability. Interobserver reliability is believed to be the most important component of implementing an interim grading scheme that limits bias from having different examiners grading annual performance.

THE DUROTOMY REPAIR SIMULATOR AS A MODEL RESIDENCY TRAINING TOOL

Unintended repair of durotomies can be frustrating, adding significant morbidity to a spine