Medical and neurosurgical training are traditionally based on the see one, do one, teach one experiential and apprenticeship model of education. This is changing. In this issue of the *Journal of Neurosurgery*, Kirkman and colleagues provide an important and timely systematic review of the use of simulation in neurosurgical training. The publications they review were too variable to allow for formal statistical meta-analysis.

Training simulations have been used for decades, maybe even centuries. Meller noted that in medicine, clay models of people were used centuries ago to demonstrate and probably teach what diseases looked like; these models were also used for diagnostic purposes so that women might even centuries. Meller noted that in medicine, clay models were used centuries ago to demonstrate and probably teach what diseases looked like; these models were also used for diagnostic purposes so that women could consult male physicians and maintain social laws of modesty. In fields such as aviation and space flight, where it is the trainee’s life that is on the line, simulations have been developed and used essentially concomitantly with the development of the actual aircraft and spacecraft. The largest flight simulator in the world is the Vertical Motion Simulator at the National Aeronautics and Space Administration in Ames, California. This simulator can mount different aircraft cabins on a base that moves 60 ft. up or down and laterally up to 40 ft. It was used to work out the cause of some landing problems with one of the early space shuttles and to prevent it from happening again. This demonstrates not only the training value, but that simulation can actually advance a field. There are examples of simulators in medicine (for example, for endovascular surgery). Many flight simulators are available, even for personal use, but as far as I can tell to become a pilot one does not actually have to do any simulation. Rather, the training is with an instructor. In business, where money, and perhaps power, is the main thing at stake, developments lagged behind, and, according to one source, the first commercially available training simulator was a game that came out in 1956 for employees to test themselves in the business world. In athletics, again arguably driven by money and power, simulation, practice, and coaching are to some extent the entire basis of advancement, assuming inate skill. Driving is a complicated task that puts the driver and others at risk, and for which privileges may be revoked by doctors. Simulators are available, but they are not widely used either in training or to assess driving after illness.

What is the state of things in medicine, and specifically the high-risk field of neurosurgery? Kirkman and colleagues note that changes in neurosurgical training, including work-hour restrictions, are driving the need for increased use of simulation to train residents. This may be true in order to not lengthen the time it takes to become certified in neurosurgery, but there are other drivers. The authors discussed many of them in their previous publication. There are now more standardized training guidelines or outlines of what is to be learned and better assessment methods. More realistic simulators are only recently becoming available for use in neurosurgery, other than cadaveric methods, and it is the development of these simulators that I think is, and should be, leading to increased use of simulation. Also, the science of learning surgery, including use of mental rehearsal and other techniques, is advancing.

Kirkman et al. searched for and initially found 4101 articles. The authors ended up reviewing 28 papers. They are to be complimented for using the recommendations for such systematic reviews (PRISMA [Preferred Reporting Items for Systematic reviews and Meta-Analyses]). A limitation is that the authors included only studies published in the English language, which could bias the results and likely account for why most of the studies came from the US or Europe. The findings are limited given the small number of disparate studies, but they are consistent with those in other fields of medical simulation. Meta-analysis of technology-enhanced simulations found that the use of simulators almost always were associated with better learning and patient-related outcomes. Cook et al. concluded that the evidence was strong enough for the benefits of technology-enhanced simulation such that further studies comparing it to nonintervention controls were probably unnecessary and that the key questions are now how and when to use simulation. In the current review by Kirkman et al., simulation improved trainee/surgeon performance after using simulators. The authors used the Medical Education Research Study Quality Instrument scale and found that the mean score was about 9 out of 18; therefore, the studies are not of very good quality. According to this score, neurosurgery is behind other surgical specialties, for example, laparoscopic surgery.
The authors discuss eloquently the use of this score as well as its limitations and advantages.

It seems likely and warranted that simulation will increase in neurosurgical training. As mentioned above, even excluding work-hour restrictions, the argument that we need more simulation training is a strong one. No matter how long a trainee is at work, the idea of learning as much as possible about the technical and other aspects of a procedure before conducting it on a person seems like a good one. As mentioned above, it is more the factors behind the work hour restrictions, such as public opinion or public knowledge about medical errors, how we train residents, and some of the limitations of the traditional apprentice style training, that are important. Is it not unusual, for example, that the first carotid endarterectomy that a resident sews up is usually in a live person? This procedure should not be difficult to model and to require 50 or some number of cases of simulated suturing with assessment of the quality of the suturing, leakage and such, before doing the real thing. Now the tools are becoming available. Use of these tools would bring us more in line with other fields like aviation, military training, and sports. Some other differences between some of those fields and neurosurgery are presence of backup during procedures and ongoing training/coaching/maintenance of competence. When beginning neurosurgical practice, these differences are particularly evident as new surgeons can theoretically be certified to undertake procedures that might be better done or at least supervised by senior colleagues. And then as we move along in years, who is watching or “coaching” the established surgeons? There is usually no copilot or coach. Certainly, the institution of recertification is helpful; however, we don’t assess, and it would be difficult to assess, technical competency. It is also not exactly quantified how much assessment of technical competency matters for most of what we do, such as bur holes for chronic subdural and routine spinal disc surgery.

Simulation is already increasingly used. In our residency program in Toronto, the starting residents undergo didactic teaching for weeks prior to starting residency and then undergo simulation-based training for simple procedures in a simulation laboratory. More could be done, but there are limitations. The higher-level residents supervise some of these sessions, which highlights that faculty are not strongly, if at all, incentivized to spend time supervising. We could use simple methods, such as rehearsal, better. Many of us rehearse the operations we do, especially ones that we don’t do every day, but having the residents go through the operation with us beforehand is not always done.

In summary, this systematic review is important. Training for surgical procedures has already moved to see one, simulate some, then do one. This review demonstrates what will become an increasingly important part of neurosurgical training and probably at some point in the future, as intimated above, the assessment of competency for recertification. At this point, this review summarizes very well the state of simulation in neurosurgery. The reader is encouraged to also read one of the authors’ other papers, which is a brief review of some of the other issues. (http://thejns.org/doi/abs/10.3171/2014.3.JNS132591)

References


Response

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On behalf of all the authors, I would like to thank Dr. Macdonald for his kind comments about our systematic review on the use of simulation in neurosurgical education and training and for his very interesting accompanying editorial to our paper. The history of the use of simulation both within and outside medical fields is indeed fascinating, and there is much that neurosurgery can learn from the use of simulation in other domains. As highlighted by Dr. Macdonald, there have been multiple drivers to the increasing use of simulation within medical settings. Such drivers include not only work-hour restrictions but also an ever-increasing focus on patient safety, surgical performance, and accountability resulting in part from high-profile incidents in which patient care has been compromised, for example, due to the working patterns of junior doctors.

The arguments in favor of simulation as an education and training tool in neurosurgery are strong. Crucially, simulation provides a safe environment for the learner to hone his or her technical skills without the risk of causing patient harm. Isn’t it therefore surprising that the field of neurosurgery, abound with operations associated with high morbidity and mortality and where technical skills are thus so vital, has been relatively slow to adopt simulation compared with, say, general surgery? Perhaps the