Surgical simulation – a ‘good idea whose time has come’

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Endoscopic surgery and advances in medical imaging have created a digital environment that, when combined with other emerging technologies, will shortly revolutionize medical education. Surgery is at the cutting edge of this frontier. Society’s demands for greater accountability and objectivity in medical performance, and the profession’s need for uniformity in training, are major driving forces. There is also pressure for cost effectiveness in training and a need to respond to the modern day reduction in the exposure of the trainee to patients. These pressures are forcing surgeons to mobilize technologies to support the competence and integrity of the profession. Features of these technologies include an increase in computer processing capacity; improvement in computer graphics that allow sophisticated digital rendition of human anatomy and physiology; advances in psychology and education that will affect the selection, training and testing of medical personnel; and advances in haptic engineering that enable the virtual environment to relate to the touch and feel of the human hand. All of this is now set against a background of general revulsion about killing animals for technical training, and a realization that allowing patients to be the subject of even closely supervised training poses an ethical question.

Simulation is perhaps best known in the world of aviation where it has been embedded for 50 years; while the world of medicine is not always analogous, aviation has much to teach us1. Medical simulators are rapidly evolving from primitive plastic mannequins to machines with embedded technology and, recently, computer assistance capable of creating realistic physiological and patient scenarios. Several procedural or part-task trainers with high-fidelity computer graphic renditions of appropriate anatomy, including deformable tissues and appropriate physiological reactions, are currently available. These are connected to bimanual devices, some with haptics, that allow suture placement or practice of endoscopic procedures, such as bronchoscopy, colonoscopy and laparoscopic cholecystectomy. The role of these simulators in assessment and training of surgeons is now being validated2,3, and a prospective, randomized, double-blind trial has shown that novices who are simulator trained to the bimanual psychomotor performance level of an experienced laparoscopic surgeon perform a laparoscopic cholecystectomy 30 per cent faster and with five times fewer intraoperative errors than those not so trained4.

Current virtual reality simulators range from simple part-task trainers, such as the Minimally Invasive Surgical Trainer – Virtual Reality (MIST-VR, Virtual Presence Ltd., London, UK) to hybrid simulators that allow breast, prostate and pelvic examination. Full procedural simulators also exist, which simulate the anatomy and physiology associated with interventions such as coronary stent or cardiac lead placement5; the Vascular Interventional Surgical Trainer (VIST) (Mentice, Gothenburg, Sweden) is an example. Some of these simulators have embedded performance metrics, but few have been validated to acceptable psychometric and scientific standards6. Much is still to be done if the potential of simulators for student-centred learning in medicine is to be fully realized.

The three fundamentals for successful integration of simulation into medical training are curriculum, metrics and validation. The curriculum must incorporate the simulator if it is to offer the added value it brings to the process of education in cognitive and technical training. Ideally, cognitive and technical task analysis by end-users should be obtained before the simulator is created. Such analysis is needed to establish bona fide metrics of performance, which must then be fully validated in a structured and robust scientific fashion. Unfortunately, studies on surgical simulators have so far failed to meet these basic requirements. Many are of poor experimental design, while others do not use reliable, valid and measurable outcomes. In summary, bad science in the field of medical simulation has been all too common; in future, journal editors and their reviewers must exercise vigilant discrimination.

Surgeon educators must acquaint themselves with the domains of knowledge that will enable successful integration of simulators into the curriculum. It is not acceptable educational practice to purchase a simulator and point novices to it with instructions ‘to train’. Surgeon educators should also understand that the simulator is a tool to be integrated into the curriculum with a clearly identified educational or technical skill acquisition goal. Furthermore, they should know the difference between skill transfer and skill generalization; although related, these fundamental features of learning are not the same7.
Skill transfer occurs when the simulated task relates directly to the operative task, for example dissection of the gallbladder from the liver with a cautery L hook. Skill generalization refers to a broader range of generic skills, for instance laparoscopic psychomotor skills, that are not directly related to the operative task to be performed but are sufficiently related to improve operative task performance, such as intracorporeal suturing.

It is worthwhile stating that simulators can provide negative training, that is to say they may establish and reinforce bad habits, to the detriment of patient care. This is no small point; it is easy to acquire a bad habit that, once learned, is very difficult to abandon and vigilance is necessary in this regard. On a more positive note, simulators have an extraordinarily powerful potential for training at the margins of practice, such as for emergency or unusual events, or difficult manoeuvres. They allow one to make errors and to learn from such errors in a non-threatening fashion, without risk to the patient. Furthermore, it should be appreciated that simulators can not only provide training in technical manoeuvres; they can also be used to teach decision making and judgement.

Simulators with embedded metrics, automated debriefing and intelligent tutoring may soon help medical students select or deselect themselves for surgical training. They should assist training programme directors in the selection and assessment of trainees, permitting certification based on established objective performance criteria, rather than by checklist and time in post. Simulators will also allow a trainee to monitor his or her skill acquisition against national or (preferably) international benchmarks. Criterion-based cognitive and technical skill assessment may ultimately become part of professional certification.

The American College of Surgeons has identified simulation as an important factor in ensuring patient safety, together with evidence-based practice and peer review. Very soon technology-assisted training will have a substantial impact on medicine worldwide; surgery is at the forefront of this change.

References