Volume 19, Number 4,
September 2004

Simulating Our Way to a Safer and More Complete Anesthesia Education

Christopher Lee Pysyk, BSc (Hons)
University of Alberta
Medical Class of 2006
Canadian Anesthesiologists' Society
Essay Contest
January 2004

Alarms clamour urgently for your attention. Blood pressure falls precipitously. The surgeon worries about the patient's status. Simple corrections do not ameliorate the situation. Multiple intervention options cloud your management plans. Questions and uncertainty abound . . .

What should I do? Who should I call? Have I ever seen anything like this before???
Perhaps more frequently than in other specialties, crises in anesthesiology present with tremendous speed and urgency. However, very few anesthesiologists have clinical experience handling these most challenging situations. Furthermore, opportunities for supervised intervention by residents and medical students in these cases are rare. Ultimately, the lack of a controlled, consistent and patient-safe manner of teaching anesthetic practice and crisis management provided the impetus for the anesthesia simulator-based training programs in use today.

Evolution of Simulators in Anesthesiology

The use of simulation for training dates back to Roman times when warriors honed their combat skills by practising on a crude model "enemy" that would strike the swordsman if he was unable to evade the counterblow.(1) Centuries later, the aviation world began using simulators that, to date, offer a very accurate representation of aircraft response to many different aeronautical scenarios. For this reason, the aviation industry relies on simulators to provide safe and cost-effective pilot training and experimentation with new aircraft and designs.

Bolstered by the success of simulators in aviation, the field of anesthesiology encountered its first mannequin-based simulator (Sim One) in the late 1960s,(2) at a time when, according to Gravenstein, "neither the technology nor the profession was ready for it."(3) Sim One consisted of a mannequin head, neck, thorax, abdomen and arms permanently mounted on a table. It exhibited several clinical features, such as palpable pulses, bucking, pupillary dilatation/constriction, laryngospasm, regurgitation of gastric contents, frowning, abdominal distention (to represent esophageal intubation), fasciculation, variable jaw tension and force-sensitive teeth/lower lips.(2,4) However, Sim One recognized only four drugs and was unable to produce output for electronic monitors to display the "patient's" status. With such limitations, many anesthesiologists were initially skeptical about the ability of human-machine interactions to accurately reflect, let alone improve, future patient encounters.

In 1969, a study was designed to test Sim One as an educational tool for anesthesia

residents. The results indicated that residents trained for two weeks on Sim One were more likely to obtain a "plus" versus a "minus" score from faculty reviewing the residents' operating room (OR) anesthetic records.(5) However, the study was flawed, since the control group received no instruction about specific intubation and induction techniques, compared to the Sim OneÐtrained group. Moreover, it is now well recognized that competence in intubation and induction skills are acquired very rapidly among residents through clinical experience and supervised practice on appropriately selected patients.(6) Consequently, the skill sets Sim One targeted did not supplant other well-established methods for training anesthesia residents at the time. Coupled with the considerable cost of Sim One (equivalent to about $450,000 US today),(6) anesthesia simulators had lost their appeal by the early 1970s, before Sim Two was constructed.

By the 1980s, the advent of relatively inexpensive microprocessors and technological advancements in the practice anesthesiology (i.e., routine intraoperative electronic monitoring) created an optimal environment for the reintroduction of anesthesia simulators. Unlike Sim One, this generation of mannequins generated output such as electrocardiograms and invasive pressure monitors that more completely portrayed the information available to anesthesiologists in today's OR environment. In addition, the newer simulators responded to more drugs and replicated physiologic disturbances of increasing complexity.

Full Potential of Anesthesia Simulators Realized

Originally intended to enhance technical skills among anesthesia residents and medical students, simulators fulfilled this role without posing risk to patients. However, it was not until the late 1980s that the true utility of anesthesia simulation, for all levels of training, began to emerge. In addition to testing technical skills, simulations conducted in a replicated OR—complete with actual drug cart, monitors and mock OR staff—were video-recorded to observe the anesthesiologist's response to various medical and mechanical problems. Video analysis in a group setting after the scenario permitted, for the first time, a systematic and interactive forum for discussion of the decisions and procedures employed by the anesthesiologist handling each simulated crisis. In addition, feedback from instructors controlling the simulation provided an effective medium for constructive criticism and identification of areas in need of improvement without jeopardizing patient care. To date, anesthesia simulator participants have consistently supported the group debriefing and discussion sessions as one of the most educationally valuable experiences of the entire simulation process.(7,8) In this way, simulators provide a conducive learning environment, complete with advice from several colleagues well-versed in the specifics of the case in question. Such qualities are unavailable in real-world anesthesia emergencies and highlight the advantages of simulator training. Upon review of the first OR simulation videotapes, several deficiencies in anesthesia residency training related to crisis management and decision making were discovered.(9,10) Gaba et al. identify three major gaps in training: a lack of systematic emergency procedures, ineffective non-technical skills for challenging situations and inadequate integration of technical and non-technical skills in emergencies.(7,9) Of these three educational problems, refining emergency technical skills appears most logically correctable through simulation. Wong et al. showed that both cricothyroidotomy success rates and time for staff anesthesiologists to complete the intervention significantly improved by the fourth attempt on mannequins.(11) Given the significant mortality and morbidity associated with unsuccessful cricothyroidotomies, anesthesia simulators offer a safe and controlled manner to improve the critical skills that both novice and seasoned physicians infrequently have the opportunity to practice.

Even if one is well trained in the technical aspects of handling an emergency, poorly

developed "non-technical" skills, such as communication with OR colleagues, leadership skills and resource management in high-risk situations, adversely affect crisis resolution. One study showed that all anesthetic crisis simulator participants scored adequately on technical skills and medical decisions made during the simulation. However, approximately one-third of anesthesiologists were rated as "substandard or minimally acceptable" on behavioural performance criteria: communication, leadership and distribution of workload.(12) This study exemplifies the usefulness of OR simulators to provide an experiential environment for identification of the intangible nuances and development of the non-technical (teamwork) skills essential in optimizing the "art" of anesthesia and crisis management.

In response to the paucity of structured learning related to decision making and resource management in anesthetic crises, simulation has become an integral component of anesthesia crisis resource management (ACRM) education. Howard et al. designed the first ACRM program based on a similar training system used in aviation, known as crew resource management (CRM).(13) Like anesthesia crises, technical incompetence was not determined to be the leading factor in the majority of aircraft emergencies; inappropriate resource management and deterioration of teamwork and communication proved more consequential in aviation mishaps.(14) In further support of teamwork-focused training for improved patient safety, a recent report from the Institute of Medicine strongly encouraged healthcare educators and organizations to implement "team training programs for personnel in critical care areas (e.g., the emergency department, ICU, and OR) using proven methods such as crew resource management techniques employed in aviation, including simulation."(15)

Conclusion and the Future of Anesthesia Simulation

The complex world of anesthesia consists of ill-structured problems presenting in a time-sensitive manner with uncertainty, shifting goals and the interaction of several key players and resources. It is here that the true power of anesthesia simulation is realized, replicating a scenario in which the anesthesiologist must act as a constructive member of the healthcare team to respond most appropriately to the situation presented. Until one is placed in a circumstance in which multiple dynamic factors demand attention, the acquisition and sophistication of the full complement of technical and teamwork skills needed to appropriately handle a crisis cannot fully develop; these skills cannot be acquired through observation and "osmosis" alone. For instance, anesthesia simulation has demonstrated its utility for teaching and refining the emergency intervention techniques that physicians of different skill levels must be able to employ. Moreover, considerable benefit from simulator-based training can be derived by filling the experiential gaps that anesthesia training programs themselves leave for several reasons: patient safety, the relative infrequency of certain emergencies, the lack of availability of a suitable learning environment for crisis management and timely instruction supported by feedback from qualified personnel. As technology and the field of anesthesiology continue to evolve, the potential for anesthesia simulators to offer more accurate, controlled, systematic and safe methods of continuing education for the practitioners of today and instruction for the anesthesiologists of tomorrow seems more promising than ever.

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