Simulation in Neuroanesthesia: How Much to Learn?

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Abstract

Taking a cue from the aviation industry, medicine took upon itself the responsibility to improve patient safety. The cause was championed by anesthesia that became a pioneer in using simulation-based training to improve the nontechnical skills, at every level of clinical training. The needs have been understood by evolving subspecialties such as neuroanesthesia as well, where a fewer number of patients and reduced margin of safety have propelled the development of simulation modules specific to requirements. The constant, ongoing advances and improvement in simulation practices have contributed immensely to the betterment of patient safety, and a significant dent in surgical morbidity and mortality probably explains why simulation-based training programs are being incorporated into teaching curriculum across the world.

Keywords
► education
► nontechnical skills
► patient safety

Introduction

Simulation has had a long and varied history in many different fields, including aviation and the military. The concept of simulation is much newer to health care than it is to aviation. Health care, like aviation, is driven by safety, more specifically patient safety. As the link between simulation and patient safety becomes increasingly apparent, simulation is being adopted as the education and training method of choice for such critical behaviors as communication and teamwork skills, better known as nontechnical skills. At the same time, reforms in education, combined with political and societal pressures, have promoted a safety-conscious culture in which simulation provides a means of risk-free learning in complex, critical, or rare situations

The historical roots of simulation might be described with the broadest definition of medical simulation: "an imitation of some real thing, state of affairs, or process" for the practice of skills, problem solving, and judgment.[1] Large collaborative simulation centers now focus on multidisciplinary, interprofessional, and multimodal simulation training. The use of simulation spans a spectrum of sophistication, from the simple reproduction of isolated body parts through to complex human interactions portrayed by simulated patients or high-fidelity human patient simulators replicating whole-body appearance and variable physiologic parameters.

Simulation learning provides medical and nursing personnel with the opportunity to develop and refine their skills without putting patients at risk. Ensuring the competence of a large number of new staff members is a challenge best met with the implementation of a simulation training program. Such a program allows as well as encourages the participation of the surgical team in scenarios such as surgical drape fires and airway fires, cardiac arrest of patients in the supine and prone positions, etc. The simulations help operating room (OR) staff members identify problems that can happen during real emergencies and help them work as a team to prepare for events that may represent life-threatening situations for patients.[2]

Clearly, anesthesia fits the criteria outlined by Orasanu and Connolly[3] in 1993 for a "complex dynamic world" in which naturalistic decision making should apply:

- Problems are ill-structured.
- The environment is dynamic.
- The environment is full of uncertainty.
- There is intense time pressure.

Why Use Simulation in Anesthesia?

Anesthesia was among the earliest medical specialties to focus on and actively work toward patient safety. Anesthesia has the most extensive experience in health care with the use

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of mannequin-based simulation for training and research.[4] Continuously evolving audits have revealed that human error is a major contributor to critical events in anesthesia. The opportunity to encounter certain rare life-threatening anesthetic emergencies, such as malignant hyperthermia, or performing uncommon anesthetic procedures, in actual clinical practice is limited. Drawing from the experiences of the aviation industry, Gaba noted that to be effective, these skills must be actively taught rather than acquired through reading about it.[5] Ericsson and Charness deduced that the crucial factor in developing expertise is the amount of deliberate practice.[6] As a result, one of the seminal uses of the high-fidelity simulator in anesthesia is in training and rehearsing for crisis management.

Once the discussion of simulation in anesthesia is underway, it is almost impossible to not go back to where it all started. In terms of a turning point, the Elaine Bromiley case categorically transformed the way patient safety was discussed and approached. The death of Elaine Bromiley demonstrates a fixation error during the management of a difficult airway. Such errors may result from a unidimensional approach to problem solving, which tends to turn a blind eye to other relevant aspects.[7] In this particular case, the unsuccessful management of an unanticipated difficult airway led to hypoxic insult and eventual death of the patient. Her husband Martin Bromiley, who was a pilot, documented his harrowed account of the events and brought up the need to approach the incident like an aviation mishap.[8] Because of his efforts, an independent inquiry showed several human-factor failings in his wife's case and led to the subsequent establishment of the first Clinical Human Factors Group, thus highlighting the importance of human factors in anesthetic training.

Besides the obvious advantage of increasing familiarity with less encountered clinical scenarios, simulation has also found a role in improving the nontechnical skills in anesthesia. As developed by Fletcher et al, these include, but are not limited to, task management, team working, situation awareness, and decision making.[9] The case of Elaine Bromiley highlights the significance of situational awareness for the anesthetist and the result of its loss in terms of "fixation error." The enquiry of this case had also revealed the collapse of communication system, with nursing staff unable to register their suggestions, despite having caught on the problem quite early. The simulation of critical real-life events, with the participation of all staff members, can improve the aforementioned nontechnical skills to a significant extent, so that "everyone knows the drill." The familiarity with protocol is what reduces the need for every instruction to be announced, thereby incorporating more of nonverbal communication. A crisis management situation in anesthesia does not solely need a clinical experience, but also its practical application in a situation in which multiple instructions given to multiple team members can result in chaos and an undesirable outcome.

Role in Neuroanesthesia

Neurosurgical anesthesia over the past decade has carved a unique and richly deserved niche for itself in the arena of medical subspecialties. Technological refinements, better and accurate diagnostic modalities, monitoring advancements, and in-depth research in areas that so far seemed implausible have propelled the growth of this subspecialty significantly.[10] Neuroanesthesia is a dynamic and rapidly advancing subspecialty in which the anesthetic technique can have a deep impact on both operative conditions and patient outcome. Here, advanced airway skills, multimodal monitoring, and the management of challenging and complex cases are required on a regular basis.

For a long time, subspecialty training was undermined and failed to receive the recognition it should have. A short duration of specialty rotation fails to provide the requisite experience and aptitude to practice neuroanesthesia. Hence the need is for meticulously designed training programs that select the best clinicians, using rigorous criteria, and then put in place a module that incorporates intensive training as well as extensive experience.

With the specific requirements of a subspecialty training being complex and refined, the challenge only increases. It becomes necessary to train each individual, providing a broad spectrum working experience. Neuroanesthesia is not a conventionally "high output" specialty, with more focus on quality than on sheer numbers. It is a specialty with little or no margin of error, hence the dilemma of providing hands-on experience to trainees, without compromising patient safety. Artificial intelligence, therefore, comes to the rescue, in ways more than one.

Uncommon situations such as cardiac arrest in the prone or lateral decubitus may be encountered during neuroanesthesia practice. Cardiopulmonary resuscitation in these positions is something even the experienced OR staff may be unfamiliar with, given the specific nature of the situation. Simulation studies have shown that identification alone of ventricular fibrillation in the prone patient is difficult and additional training is required for the same.[11] Simulation sessions of such critical events regularly allow each member of the OR staff to identify and practice a predetermined role, thus minimizing the contribution of human error. It is an excellent way for new recruits, doctors and nurses alike, to feel at ease with and work in the neurosurgical unit. Advances in intraoperative neuromonitoring have contributed enormously to the success and safety of neurosurgical procedures. Simulation sessions with the use of these techniques is also finding acceptance widely.

One brain neuroanesthesia simulation program, originally developed in Bristol, United Kingdom, is a successful example and is now being adopted in several other countries.[12] It was designed by a group of senior trainees and consultant neuroanesthetists with an interest in the safe management, stabilization, and transfer of neurosurgical emergencies in the acute peri- and postoperative period. It comprises lectures on neurosurgery, neuroanesthesia, and anesthesia for neuroradiology, and encompasses extensive simulation training, giving the candidates an opportunity to run through scenarios and emergencies they might encounter when actually working.[13] A separate session is dedicated to the journey of a patient with a head injury through their initial presentation to the emergency department, through to theaters, and then finally to the neurointensive care unit. The key areas covered include the following:

- Immediate management of the head-injured patient.
- Venous air embolism.
- Subarachnoid hemorrhage-associated vasospasm.
- Raised intracranial pressure in the intensive care patient.
- Transfer to definitive care center.

Given the limited number of patients, neuroanesthesia trainees get to work with during early training, and the stakes involved, simulation-based training becomes more of a necessity than just a supplement. All the scenarios enlisted above are what we encounter nearly daily in the OR and the intensive care unit (ICU). Improving our preparedness, therefore, is only logical.

A very important aspect of training in any specialty is standardization of training. This aspect of application of simulation is more relevant for a country such as India. There is primarily a deficiency of an adequate number of centers that have a facility for neuroanesthesia training in India. Among the existing ones, an inherent difference remains in terms of the number and type of patients treated. A particular center may be dealing with a higher number of trauma cases, whereas another may be catering to neuro-oncology overload. This reflects on the training programs in the teaching hospitals, leading to discrepancy. The rising need for neuroanesthetists and neurointensivists is challenged the most by lacunae in training programs. An effective tool to minimize this skew is to incorporate and emphasize on simulation-based training. As the latter can be as repetitive and uniform, as desired without causing inconvenience, it can help in ironing out major differences in teaching modules.

Even if we look beyond core neuroanesthesia training, we find the growing utility and scope of simulation-based training. At a large number of centers, the first clinician that comes in contact with patients of trauma, stroke, or spinal injury may be a physician or a general surgeon. At smaller centers, it may only be a medical graduate with no specialist training. Ensuring the availability of a neurosurgeon or neuroanesthetist in every emergency room is not feasible and too resource intensive. It is far more likely that with the use of short-term training modules, using simulation primarily, we can have a much larger number of trained clinicians who can manage an emergency scenario safely and effectively, until the patient can be referred to a higher center. Instruction in basic principles of neurophysiology, hemodynamics and airway management, and safe transfer of patients is easily achieved with simulation courses. The initial management of a neurologic emergency bears immense impact on the eventual prognosis, and this is where the use of artificial intelligence can certainly revamp the existing system.

Role in the Critical Care Unit

Besides the OR and emergency room, simulation training also finds a significant role in the critical care unit, especially in staff training. Smith and Jankowski found that engaging the staff by implementing a regular simulation-based team training program, they were able to boost the skills, knowledge, and, ultimately, confidence levels in treating traumatic brain injury among these groups of staff.[14] They observed that the potential for undertreatment of the underlying brain injury and serious neurologic sequelae is high, especially if staff on the general ICUs on which these patients are treated lack confidence in this area of practice.

A simulation-based course has been widely shown to improve knowledge retention, teamwork, and crisis management in various groups of hospital staff, including nurses. It allows the use of teaching methods that provide valuable and timely feedback and allow for repetitive practice in a safe environment conducive to adult learning. Given the high volume of changing staff in the critical care unit, real-time experience with crisis situations may be limited. Simulation of the same situations, however, is feasible. It also allows educators to measure outcomes related to specific learning objectives.[15] There is a growing body of evidence that it can lead to error and cost reduction and increased patient safety in high-risk circumstances.

Where Does It Fail?

For obvious reasons, simulator-based training cannot replace traditional clinical teaching. This, coupled with the cost factor, has worked against a more widespread use of simulator-based curriculum, especially in a resource-strung health care like ours. That remains an essential difference between aviation and medicine in terms of dependence on the concept of simulation. Kinnear challenged the conviction that simulation training holds the key to improving critical incident management in anesthesia, a model that has largely been derived from the airline industry, way back in 2010.[16]

He opined (further derived from observations of the safety editor for *Flight International* magazine) that the increased number of airline accidents and near misses were due to an over-reliance on simulator training with consequent loss of the basic skills to fly an aircraft should the high-tech equipment fail. If we were to draw a parallel to clinical teaching in medicine, this would imply that an overdependence on simulation could take away the basic skills and reflexes that come with day-to-day learning with real patients. It would be reasonable to state that the anxiety and even fear that is felt in real-life crisis situation cannot be reproduced with simulation, irrespective of fidelity. As cited by Kinnear, Schmidt et al theorize that the expertise we develop is based on cognitive structures ("illness scripts") that do not rely on reasoning or pathophysiologic models but on contextual associations that derive from dealing with real patients in authentic circumstances.[17] To a significant extent, clinical experience and aptitude incorporate a psychological component that is missing with simulation. In other words, the experience that we accumulate with real-life crisis management is not only different from but also superior to the one extracted from simulation situations, as the participant is always aware that the crisis is staged. More than a flaw of simulation itself, this is a cognitive limitation of the human mind.

Conclusion

There is a reason simulation-based training has been successful in aviation, despite the drawbacks listed previously. In addition, these should not deter us from evolving newer simulation modules, in an attempt to re-create crisis-induced stress response. The concept of distributed situational awareness has added another dimension to simulation-based practice.[7] For simulation to realize its potential impact, further research is needed to understand how to optimize this modality of learning more effectively. In future, the optimal use of simulation will depend on a clear understanding of what can and cannot be accomplished with simulation and its various modalities. Its success in other countries bears weightage and calls for a closer and a more serious consideration.

Conflict of Interest
None.

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