Narrative Review

Integration of simulation-based teaching in anaesthesiology curriculum

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ABSTRACT

Simulation refers to the replication of various elements of a real-world situation to achieve pre-specified objectives by enabling experiential learning. As the global burden of preventable medical errors remains high, simulation-based teaching may be used to standardise medical training and improve patient safety. With the same intent, the National Medical Commission has adopted simulation as part of the Competency Based Medical Education approach. Simulation-based training creates immersive and experiential learning, which keeps the new generation of learners actively involved in the learning process. Simulation is widely used to impart technical and non-technical skills for postgraduate trainees in anaesthesiology, but it is still not integrated as a structured part of the curriculum. This article aims to identify technical and non-technical skills that can be taught using simulation and suggests opportunities for using the existing infrastructure and resources to integrate simulation as part of the anaesthesiology training curriculum.

Key words: Crisis resource management, curriculum integration, fidelity, infrastructure, non-technical skills, simulation, technical skills

INTRODUCTION

Simulation-based teaching (SBT) has become integral to medical education and training worldwide. It offers the unique opportunity of learning safely and ethically without compromising patient safety.[1] Training can also be imparted for rare and unusual events which may not be encountered in clinical practice. The introduction of SBT into the training curriculum of anaesthesiology residents can be achieved by identifying technical and non-technical skills that can be best imparted through simulation. The same can be executed with the help of optimal utilisation of available resources to enable students to learn better.

CURRENT CHALLENGES IN MEDICAL EDUCATION

Traditional medical training was based on the Halsted apprenticeship model of 'See one, Do one and Teach one'.[2] However, this model might not be appropriate because patients might be harmed during students' learning curve before they achieve competency. With SBT, learners can have repetitive, deliberate practice in a safe environment where their actions will not cause harm. The current 'Generation Z' students born into technology seldom relate to didactic lectures and classroom teaching and learn meaningfully only when they are actively engaged or immersed in experiential learning by adapting technology and innovation that are feasible with SBT.[3]

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Simulation-based training in anaesthesia

The record of the first simulation in anaesthesiology dates back to Dr Peter Safar's demonstration of mouth-to-mouth respiration in a paralysed individual.[4] Subsequently, in 1961, the first simulator in anaesthesia "Resusci Anne", was born.[5] The pace of development of simulation training has been rapid with advancements in computer technology. Today, complex software-based systems capable of replicating physiology are available; examples include SimMan by Laerdal and Human Patient Simulator (HPS)-2 (METI®, Sarasota, FL). The field is constantly evolving.[6]

Imparting technical skills via simulation in anaesthesia

Simulation has been strongly recommended as a technique for imparting skills during the initial part of medical training.[7] Standard procedures expected to be performed by a resident should be taught initially using simulators in a risk-free environment. Domains such as airway management, point-of-care ultrasonography (POCUS), obstetric anaesthesia, regional anaesthesia, trauma, intensive care, critical events, professionalism, and difficult conversations have been identified as high-priority skills for anaesthesiology trainees following an Utstein-style meeting.[1] The technical skills can be readily integrated into the teaching curriculum.

Vascular cannulation: Various simulators are available to gain proficiency in vascular cannulation – peripheral, central, or arterial. SBT has been shown to improve trainees' first-attempt rates of vascular cannulation.[8] This is specifically true for ultrasound-guided procedures combining visuospatial skills with hand-eye coordination.

Airway Management: Airway management involves performing complex procedural techniques with a time constraint under critical situations. This also requires proficiency in making quick decisions based on the clinical condition and mastery of non-technical skills to efficiently execute the decisions, especially if a difficult airway is encountered. The crisis is not routinely engaged in clinical practice; therefore, the decay of these technical and non-technical skills is inevitable with time. SBT may mitigate this by rehearsing these situations in a controlled environment and managing knowledge translation and retention.

Regional anaesthesia: SBT allows trainees to repeatedly practice procedures like needling and nerve blocks safely.[9] It may also help them get acquainted with rare situations like local anaesthetic systemic toxicity (LAST) management. Regional anaesthesia simulators may be inorganic (for example, gel pad), which help teach procedural steps, dexterity, target identification, and needling techniques. Organic simulators (for example, meat) allow better tactile sensation and sono-anatomy.

POCUS: SBT may improve competency in image acquisition, interpretation, and integration of this information into decision-making. Learners may practise in phantoms to gain sufficient confidence to perform the scans at the patient's bedside. Learners can repeatedly practise image acquisition guided by real-time feedback from the supervisor in a stress-free environment devoid of patient discomfort.[10]

Trauma: The trauma teaching and training course utilises multiple simulation modalities for over four decades to improve trauma care worldwide.[11] The trauma simulators range from low-fidelity tube thoracostomy manikins to virtual reality constructs providing experiential learning. Most errors in the management of trauma victims arise from improper triage and non-recognition of evolving life-threatening injuries. These may be mitigated by the non-technical skills learnt via SBT.

Cardiopulmonary resuscitation (CPR) skills: anaesthesiologists are integral to every hospital's code blue team. Skills required for the identification and resuscitation of a cardiac arrest victim, both basic and advanced, should be the earliest skills to be taught within the first few weeks of anaesthesiology training. Resuscitation should be part of boot camps, and 3–5 training sessions should be conducted at the beginning of residency to familiarise trainees with standard procedures, protocols, and necessary cognitive and social skills.[1]

Simulation training for non-technical skills

Conventionally, formal medical education focuses on knowledge and technical skills specific to each medical speciality. Technical skills can be taught in lectures and practicals and at the bedside. However, non-technical skills are equally important in providing safe medical care to the patient. There is seldom a standard curriculum for teaching non-technical skills. SBT is an excellent way to fill this lacuna for training on human factors. Anaesthesiology as a medical speciality pioneered crisis resource management into its curriculum when the first anaesthesia crisis resource management (ACRM) course was designed in 1990.[12] ACRM involves the creation of complex medical scenarios which require critical thinking and decision-making while interacting with several personnel. Deciding the goals and constraints for implementing a particular CRM programme to achieve a training session best suited to the learner's needs is essential.

Advanced communication skills are essential facets of safe and effective clinical care. Inappropriate communication can potentially break down the entire doctor–patient relationship. Evidence suggests that SBT may be used to improve communication skills.[13] Working with actors as simulated patients (SPs) may expose learners to various challenging behaviours. Learners engage with SPs using active listening techniques and empathy in a safe and realistic environment. This allows them to build their patient-relationship competencies.

SBT may create a situation to impart learning of complex technical and non-technical skills while running a crisis management scenario. A typical example may be an obstetric patient with a difficult airway with a 'Can't Intubate, Can't Oxygenate' situation leading to maternal cardiac arrest within a short period. This would involve coordinated teamwork between obstetricians, nurses, anaesthesiologists, and neonatologists. The case is challenging as it involves simultaneous management of 'two patients', and the learners must demonstrate airway and crisis resource management skills [Table 1].

Setting up a simulation centre

Low-cost solutions: Focus on fidelity and realism

Low- and mid-technology manikins (e.g., CPR and airway trainers) are predominantly task trainers and are used to impart technical skills. The high-technology simulators (e.g., SIM Man, HPS) are full-body size manikins capable of performing a broad range of actions, including responding to questions, blinking eyes, breathing, having a pulse rate, and heart rate. These simulators replicate human anatomy and physiology to a great extent and provide an immersive experience to the participants.

A common perception is that a high-technology simulator is often best for imparting knowledge or behaviours. Reliance on technology in simulation

Table 1: Common scenarios for complex technical teaching and non-technical teaching

Course	Scenarios*	Remarks
Crisis management	• Difficult airway management • Cannot ventilate, cannot intubate • Rapid sequence induction • Local anaesthetic systemic toxicity • Failed regional • High spinal • Intraoperative unexplained tachycardia • Massive haemorrhage • Patient awareness during anaesthesia • Intraoperative desaturation during one-lung ventilation • Anaphylaxis • Increased airway pressure • Cord prolapse • Post-partum haemorrhage • Eclampsia • Maternal arrest • Paediatric difficult airway • Fire in the airway • Post-operative infection • Post-operative airway bleeding • Post-operative hypoxia • Perioperative myocardial infarction • Pulmonary embolism • Sepsis • Acute respiratory distress syndrome	Following to be addressed • Complex technical skills • Decision making • Situational awareness • Teamwork • Task management • Role allocation • Leadership • Closed loop communication • Clear communication • Anticipation and planning • Resource allocation • Task delegation • Triage and prioritisation Multidisciplinary: involving stakeholders from other departments of the same profession Interprofessional: involving stakeholders from other professions like nurses, technicians, administrators, etc.

*Scenario list is representative and not exhaustive is an exaggeration. Simulation should be looked at as a technique rather than technology for teaching. Low- and mid-technology manikins can effectively deliver non-technical and technical skills when used with experience and expertise. Realism in simulation refers to how closely it represents situations as in real life. Realism is vastly different from pretence. In simulation exercises, the participants must perform a task and not pretend to do it. The level of realism desired for a particular exercise depends upon a multitude of factors like the nature of the simulator training, the level of experience of the learners, the objectives of the training module, the kind of equipment available, and the cost and capacity of the training exercise to impart knowledge. Low-cost alternatives are readily available when the learning objectives are clearly defined [Table 2]. Low-cost fiberoptic bronchoscopy trainers can be constructed, which are anatomically accurate and real-scale with appropriate similarities in views between the trainer and real patients.[14] Similarly, Schroeder *et al*.[15] designed an inexpensive gel phantom model for ultrasound-guided airway examination training using a porcine laryngotracheal complex embedded in a gelatin and psyllium husk-based gel.

Site

Typically, simulations were conducted at dedicated training centres, termed off-site simulation (OSS). Usually, these centres are complex setups with expensive infrastructure. However, the learning experience may be enhanced with training in a routine environment with the usual clinical team. Thus, the *in situ* simulation (ISS) concept was developed. It is not necessary to have a state-of-the-art simulation laboratory for *in situ* simulation. Any available area may be used for the same purpose. A pre-operative area may be cordoned off to be used as a training area later in the day when it is relatively free. A manikin kept on an operation theatre table when not in use may be used to create a crisis resource management scenario. Existing areas can be converted into small group immersive and intense teaching zones for imparting SBT [Figure 1]. All teams should train together to have positive outcomes despite the constantly changing, complex, and evolving clinical conditions. Non-technical skill teaching and scenarios for complex technical skills should ideally involve residents and consultants from other departments closely working with anaesthesiologists and other personnel like nurses and technicians. Areas in the operation theatre complex that can be utilised based on the time of the day are represented in Figure 2.

Teaching and learning are pleasantly contagious. Once the value of ISS is palpable in the organisation, proposals to invest in better simulators and a dedicated space might become readily accepted by the hospital administration. Collecting data and feedback from learners and integrating them to design feasible quality improvement projects

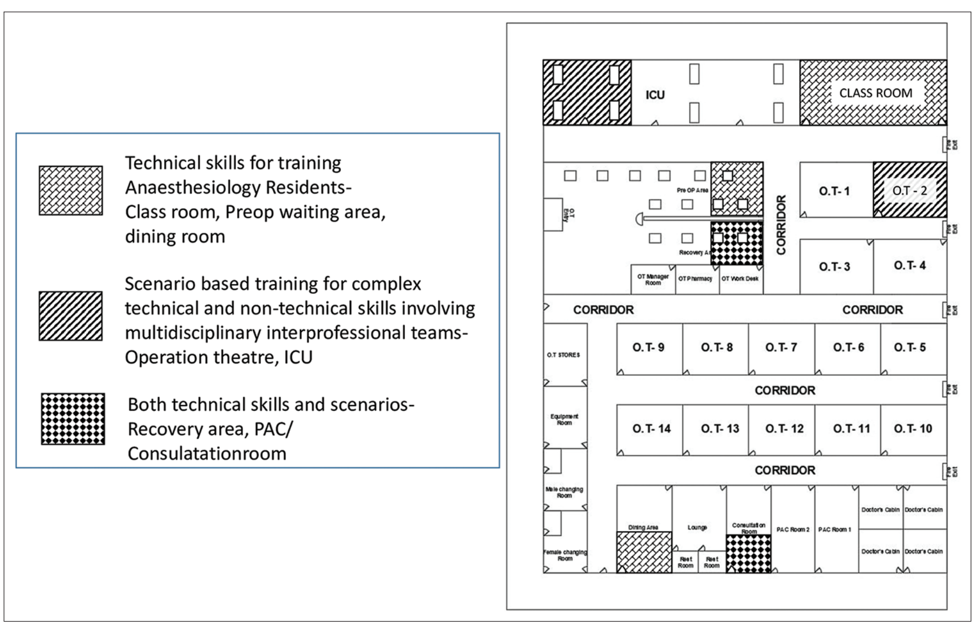

Figure 1: Areas of the OT complex that can potentially be utilised for the type of skills and participant mix. This figure only represents the OT complex, not to scale or utility. Suggestions are made to map areas that can be best used for imparting *in situ* simulation-based training. ICU= Intensive Care Unit, PAC=Preoperative Anaesthetic Checkup, OT=Operation Theatre, Preop=Preoperative

Table 2: Planning technical courses with the existing manikins

Course	Salient skills*	Readily available manikins and solutions without heavy initial investment**
Vascular cannulation	1. Intravenous (IV) cannulation 2. Central venous cannulation 3. Arterial cannulation	IV arm IV torso Ultrasound (USG) machine Gelatin-based model for ultrasound-guided vascular placement[16] Arterial arm
Airway management	1. Bag mask ventilation 2. Oral and nasal airway insertion 3. Supraglottic airway (SGA) placement and intubation through SGA 4. Direct laryngoscopy and intubation 5. Videolaryngoscopy 6. Fibreoptic bronchoscope (FOB) guided intubation 7. Airway ultrasound 8. Front of Neck Access (FONA)	Airway manikin Fibreoptic bronchoscope (FOB) Low-cost FOB trainers[14] USG machine (To be used on a volunteer for scanning airway USG) Porcine trachea for ultrasound-guided airway assessment[15] Sheep trachea (For FONA)
Regional Anaesthesia	1. Knobology and principles of USG 2. Upper limb blocks 3. Lower limb blocks 4. Truncal blocks 5. Hand-eye coordination 6. Needling techniques	USG machine (To be used on a volunteer for scanning) Gelatin-based model for needling techniques[17] Wet models for needling, e.g., chicken breast
Point of Care Ultrasound	1. Knobology and principles of USG 2. Lung USG 3. Cardiac USG 4. Focused Assessment with Sonography for Trauma (FAST) 5. Gastric USG- To determine aspiration risk	USG machine (To be used on a volunteer for scanning)
Trauma	1. Primary survey 2. Secondary survey 3. Airway management (Mentioned earlier) 4. C-spine stabilisation 5. Needle decompression 6. Intercostal Chest drainage placement 7. Vascular access placement (mentioned earlier) 8. Intraosseous (IO) line placement 9. FAST 10. Others- pelvic binder, log rolling, helmet removal	Medium technology full body manikin Low-cost chest drainage simulators Chicken leg (for IO line) USG machine (To be used on a volunteer for scanning)
Resuscitation	1. High-quality CPR 2. Airway management 3. Breathing 4. Defibrillation 5. Cardioversion 6. Advanced Cardiac Life Support 7. Post cardiac arrest care	Low technology CPR manikin Rhythm generators Defibrillator Airway manikin
Critical Care	1. Vascular cannulation (already mentioned) 2. Non-Invasive Ventilation 3. Physics of mechanical ventilation 4. Waveforms 5. Initiating and trouble-shooting the ventilator 6. Understanding alarms 7. Haemodynamic monitoring	Mechanical ventilator with circuits

*The list is not exhaustive and mentions the salient skills to be covered. Skills should be accompanied by the relevant knowledge base. **The list only mentions manikins that will most likely be available in skill labs of most medical colleges as per the mandate of undergraduate competency-based medical education. The list does not extensively cover all available manikins. High-technology solutions and simulators are not mentioned

will help faculty and other stakeholders remain motivated. Once the results of SBT are visible, opportunities for presentations in conferences and publications increase. Thus, creating an immersive learning culture can become a positive vicious cycle among all departments in the hospital. Challenges of availability of appropriate trainers and measures to address sudden increases in workload/staff shortage

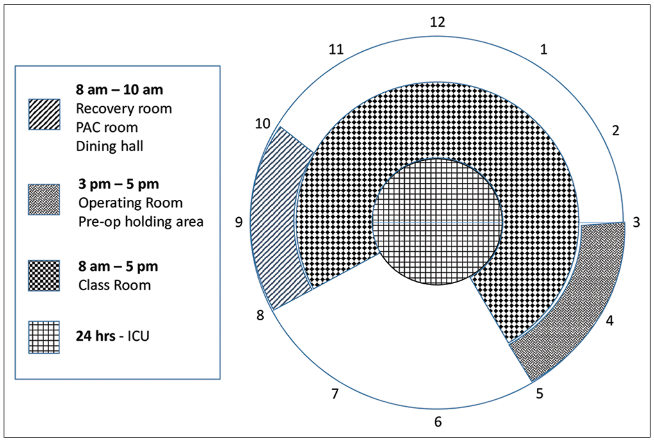

Figure 2: Locations can be utilised for training based on the time of the day. Suggestions have been given considering the routine inflow of patients in most of the hospitals. Both time and space can be modified based on availability

in on-site simulation should be worked out as the programme expands.

Faculty development

Scenario scripting and debriefing are essential components of any simulation exercise. Debriefing is a reflective discussion about the emotions, experiences, and feedback between the participants and the facilitator. The facilitator plays a passive role by allowing the participants to be self-reflective and may only provide feedback in some cases. Less than 30% of simulation instructors have received formal training in simulation in low-to-middle-income countries. Thus, it is essential to encourage faculty to train in simulation so that the logistics of conducting sessions are shared.[18] There is a definite need for a formal, structured model for developing quality facilitators.

Simulation for assessment and feedback

Assessment of learners is a core concept in medical education, which aims to ascertain quality. Many assessment modes are available, including multiple-choice questionnaires, assessing skill acquisition or performance, and Objective Structured Clinical Examination (OSCE). The effectiveness of these assessment methods has been questioned, leading to the development of realistic performance-based assessment techniques. Simulation can also be an effective formative assessment tool besides imparting knowledge. Simulation-based summative assessments may be used to establish proficiency in various specialities, which is also helpful for certification and licensure decisions.[19] Simulators may be used to assess and improve individual and team performances.

Challenges towards implementation of SBT in India

The National Medical Commission (NMC) of India has provided guidelines for a competency-based training programme for MD anaesthesiology curriculum where the list of skills expected to be acquired by a postgraduate medical student during the course has been specified.[20] The majority of these skills may be taught with the help of an appropriate simulator. Moreover, the non-technical skills mentioned may require simulation-based teaching for better student comprehension and retention. NMC encourages the use of simulators for training high-risk but low-occurrence events as well as for assessment purposes. As per NMC regulations 2020, having a skills laboratory in medical colleges is essential. Unfortunately, it is not uncommon to find medical institutions not having a functional simulation laboratory or not giving adequate time and recognition to faculty involved in simulation and medical education. A contention against using simulation in India is the belief that 'there are plenty of patients' for trainees to learn.

A significant setback to simulation-based medical education is the cost and infrastructure involved: the setup, administration, and faculty training may collectively result in high costs. This fact cannot be ignored.[21] Another limitation is that though simulation replicates the real scenario, it can never achieve the human body's complexities. Learners must spend time with real patients – something that even the best simulation programme cannot replace. Technological advancements should not pose a threat to human aspects of patient care: simulated patients may not evoke emotions and empathy in the learners. Furthermore, the availability of trained faculty with knowledge of the curriculum and simulation technology and debriefing is also a limitation for SBT. Even the most advanced simulators cannot be educators themselves, and trained facilitators are required for simulation training.

The most significant limitation of simulation-based education is the lack of good-quality validation studies.[22] Although simulation has improved technical and non-technical skills, the evidence that this improves patient outcomes remains elusive.

FUTURE OF SIMULATION IN ANAESTHESIA TRAINING

Any near miss averted due to structured training in simulation should be documented. Translational simulation refers to how training is translated to actual improvement in clinical practice, an area that needs research. DOPS (Direct Observation of Procedural Skills) may help identify gaps in learning while simultaneously providing structured feedback. Tele-simulation and incorporating artificial intelligence and machine learning to assist in skill assessment are potential areas for future research.

CONCLUSION

Immersive and experiential learning is the need of the hour to teach technical and non-technical skills, which can be achieved through SBT. Integration of SBT into the anaesthesiology curriculum can be achieved using the existing infrastructure, resources, and human resources.

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Conflicts of interest

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REFERENCES

1. Savoldelli GL, Burlacu CL, Lazarovici M, Matos FM, Østergaard D. Integration of simulation-based education in anaesthesiology specialist training. Eur J Anaesthesiol 2024;4:43-54.
2. Kotsis SV, Chung KC. Application of see one, do one, teach one concept in surgical training. Plast Reconstr Surg 2013;131:1194-201.
3. Eckleberry-Hunt J, Lick D, Hunt R. Is medical education ready for generation Z? J Grad Med Educ 2018;10:378-81.
4. Safar P. Mouth-to-mouth airway. Anesthesiology 1957;18:904-6.
5. Lind B. The birth of the resuscitation mannequin, Resusci Anne, and the teaching of mouth-to-mouth ventilation. Acta Anaesthesiol Scand 2007;51:1051-3.
6. Bhagwat M. Simulation and anaesthesia. Indian J Anaesthesia 2012;56:14-20.
7. L'Her E, Geeraerts T, Desclefs JP, Benhamou D, Blanié A, Cerf C, *et al*. Simulation-based teaching in critical care, anaesthesia and emergency medicine. Anaesth Crit Care Pain Med 2020;39:311-26.
8. Jabri G, Binhomaid M. Impact of simulation-based training on central venous catheterisation among first-year emergency medicine residents: Cross-sectional pre and post-study. Eur J Emerg Med 2020;27(Suppl 1):e17. doi: 10.1097/01.mej.0000697888.65237.86.
9. Kumar AH, Udani AD. Simulation in regional anesthesia. In: Mahoney B, Minehart R, Pian-Smith M, editors. Comprehensive Healthcare Simulation: Anesthesiology. Comprehensive Healthcare Simulation. Cham: Springer; 2020. doi: 10.1007/978-3-030-26849-7_21.
10. Gibbs V. The role of ultrasound simulators in education: An investigation into sonography student experiences and clinical mentor perceptions. Ultrasound 2015;23:204-11.
11. Carmont MR. The advanced trauma life support course: A history of its development and review of related literature. Postgrad Med J 2005;81:87-91.
12. Gaba DM. Crisis resource management and teamwork training in anaesthesia. Br J Anaesth 2010;105:3-6.
13. Blackmore A, Kasfiki EV, Purva M. Simulation-based education to improve communication skills: A systematic review and identification of current best practice. BMJ Simul Technol Enhanc Learn 2018;4:159-64.
14. Di Domenico S, Simonassi C, Chessa L. Inexpensive anatomical trainer for bronchoscopy. Interact CardioVasc Thorac Surg 2007;6:567-9.
15. Schroeder KM, Ramamoorthy J, Galgon RE. An easily made, low-cost phantom for ultrasound airway exam training and assessment. Indian J Anaesth 2013;57:31-4.
16. Morrow DS, Broder J. Cost-effective, reusable, leak-resistant ultrasound-guided vascular access trainer. J Emerg Med 2015;49:313-7.
17. Rippey JCR, Blanco P, Carr PJ. An affordable and easily constructed model for training in ultrasound-guided vascular access. J Vasc Access 2015;16:422-7.
18. Seethamraju RR, Stone KP, Shepherd M. Evolution of a simulation faculty development program in a low-resource setting. Simul Healthc 2022;17:e122-7. doi: 10.1097/SIH.0000000000000563.
19. Boulet JR, Smee SM, Dillon GF, Gimpel JR. The use of standardised patient assessments for certification and licensure decisions. Simul Healthc 2009;4:35-42.
20. National Medical Commission 2019. Guidelines for competency based postgraduate training programme for MD in Anaesthesiology. Available from: https://www.nmc.org.in/wp-content/uploads/2019/09/MD-Anesthesia.pdf. [Last accessed on 2023 Dec 20].
21. Zendejas B, Wang AT, Brydges R, Hamstra SJ, Cook DA. Cost: The missing outcome in simulation-based medical education research: A systematic review. Surgery 2013;153:160-76.
22. Young S, Dunipace D, Pukenas E, Pawlowski J. Can simulation improve patient outcomes? Int Anesthesiol Clin 2019;57:68-77.