The Journal of Education in Perioperative Medicine

Original Research

Simulation-based Airway Management Training for Anesthesiologists – A Brief Review of its Essential Role in Skills Training for Clinical Competency

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Airway Management Guidelines for Anesthesia

Difficult airway management has long been recognized as one of the most challenging tasks confronting anesthesiologists and other healthcare providers. In clinical practice failure of airway management is a significant source of patient morbidity and mortality even in recent decades.[1]

The American Society of Anesthesiologists (ASA-DAM) published "Practice Guidelines for Management of the Difficult Airway" in 1993, updating it in 2003 and 2013.[2,3] ASA-DAM guidelines provide recommendations and cautionary guidelines for anesthesiologists regarding safe airway management during anesthesia, emphasizing the need for preoperative physical or physiological examination, an appropriate preplanned strategy, and adequate emergency airway equipment. In particular, the guidelines suggest the immediate use of supraglottic devices (SGD) in cases of difficult or impossible ventilation. Furthermore, ASA-DAM recommends application of several alternative technical skills for techniques such as use of a gum elastic bougie or advanced invasive airway management in cases of difficult airway management.[4] Difficult airway management is a time-critical task to ensure adequate pulmonary gas exchange, primarily when there is relatively rapid decline in arterial oxygen content and oxyhemoglobin saturation in patients without a patent airway. Anesthesiologists are expected to perform rapid and definitive airway management using various techniques, all focused on maintaining adequate oxygen delivery to vital organs, especially the brain.

Simulation Training for Airway Management

Simulation-based medical education (SBME) has been implemented widely in skill training of various clinical specialties, including anesthesia, emergency medicine, and surgery. SBME is an educational technique used globally, in virtually all US medical schools, and is endorsed for physician Maintenance of Certification in Anesthesia (MOCA) by the American Board of Anesthesiology.[15] Experiential learning for competency-based training and assessment has demonstrable advantages, especially when employed within a mastery learning and deliberate practice instructional design.[6] Simulation-based airway training, incorporating proven experiential learning designs, offers the opportunity to accelerate learning and optimize learning outcomes.

Broad adoption of SBME in the past few decades has been driven by patient safety concerns, focused on improving the quality of medical services and clinical outcomes.[7,8] Simulation for airway management training has become popular, with demonstrated advances and effectiveness in many settings and countries, affirming the validity and superiority of simulation-based skill training methods.[9,10] Requirements for improved airway management training have resulted in development and global implementation of a wide variety of simulation-based airway training programs and courses.

Simulation Training for Technical Skill Acquisition

Airway management skills require application of complex procedural techniques, often under time constraints and clinically critical circumstances. With the development of simulation-based techniques and increased investment in medical education, simulation is playing an important and increased role in airway management training, with demonstrated sustained learning outcomes.[11] One meta-analysis has documented that simulation-based airway management training can effectively increase learner satisfaction, knowledge, technical skills, and patient outcomes compared with traditional learning strategies.[12]

SBME associated development and maintenance of airway management skills is not limited to trainees. Limited incidence of and experience managing difficult airways in clinical practice poses a risk of deterioration of advanced airway skills for practicing senior anesthesiologists. Simulation experiences allow practitioners the opportunity to practice and maintain infrequently applied DAM skills.[11]

As a "gold standard" tool for difficult airway management, the bronchofiberoscope (BFS) has become a ubiquitous device for airway management professionals, especially anesthesiologists. The BFS is used by anesthesiologists not only as an aid for tracheal intubation but also for confirmation of endobronchial pathology.[13] BFS-guided intubation is an essential

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skill that is technically challenging for anesthesiology residents to master during training, requiring complex hand–eye coordination. Traditional didactic preparation and observation is insufficient to enable novice doctors to perform this procedure safely in the operating room, even under close supervision.[14] Several publications indicate that the BFS-guided intubation instruction incorporating simulation is superior to traditional didactic training methods.[15–17]

Invasive emergency airway access skills, such as cricothyrotomy, are not applied by anesthesiologists in clinical patients on a regular basis, yet these skills are critically important for lifesaving in difficult airway management when intubation and ventilation are not possible; namely, in "can't intubate and can't ventilate (CICV)" situations.[2,18] While this emergency situation is rare, every anesthetist should maintain continuous competency to effectively and safely perform lifesaving invasive airway access should the situation arise unexpectedly, as it usually does.

The available literature provides some evidence that systematic teaching in simulation-based training can improve both confidence and practical skills of healthcare professionals to acquire and maintain invasive airway management skills.[10–12,19] A systematic review and meta-analysis of simulation- versus non–simulation-based airway training identified advantages in simulation-based training regarding learner interest, self-confidence, behavior performance, and examination scores.[10]

Simulation Training for Nontechnical Skill Acquisition

Nontechnical skills can be generally defined as "the cognitive, social, and personal resource skills that complement technical skills, and contribute to safe and efficient task performance."[20] Nontechnical skills enhance workers' technical skills and typically incorporate teamwork skill domains, such as situation awareness, decision-making, communication, teamwork, leadership, and management of stress and fatigue. Nontechnical skill training is routinely incorporated as an element of patient safety training programs. Deficiencies in nontechnical skills may increase the risk of error, which in turn increases the risk of an adverse event or clinically relevant adverse outcome. Simulation training is a valuable and effective instructional tool for both technical skills and nontechnical, behavior-based crisis management skills.[21] Both technical and nontechnical skills are required to ensure effective clinical outcomes and safety of patients during the perioperative period. Contemporary simulation instructors are devoting increased time and resources to crisis management skill training, and many simulation training centers are committed to integrating nontechnical skills simulation curricula.[22]

Virtually all anesthesiologists will experience the stress of managing a difficult airway and, more specifically, a CICV situation.[23] Because crisis conditions are low-incidence events in clinical practice, both the technical and nontechnical skills required for managing these crises are unlikely to have been rehearsed, practiced, or experienced in the months or even years preceding the requirement for emergent application of clinical skills. Decay of skills learned during training—but not regularly incorporated into clinical practice—is inevitable. One advantage of simulation training over traditional medical training methods is provision of a safe environment for crisis management training, a powerful enabler in the development of lifelong learning strategies to manage uncommonly encountered clinical crises. Thus, SBME becomes a tool to more effectively manage specific knowledge translation and retention.[8]

SBME and training are effective for developing nontechnical skills, such as situation awareness, cooperation, decision-making, leadership, and communication in emergency situations.[24] The operating room environment differs from other hospital environments in various key factors. For example, in the operating room, patients are usually continuously monitored, and key medical factors (such as body weight and relevant past history) is clear to the management team at the time of crisis management. Furthermore, the cause of crisis is often clear (eg, hypoxia due to impossible ventilation). Another major difference in the operating room is the restricted nonverbal communication necessary when wearing masks and goggles. Thus, the perioperative crisis management team differs from that of emergency medicine or critical care, leading to modified nontechnical-skill evaluation tools based on unique operating room characteristics. Thus, modification may include "shared situational awareness between operative and nonoperative fields" and "effective verbal communication between operative and nonoperative fields."[25]

Limitations and Challenges of Simulation-based Airway Management Training

SBME is an evidence-based experiential learning educational method to address the complex problem of degraded clinical skills due to inadequate clinical practice and experience. SBME provides the opportunity for anesthesiologists to practice technical and nontechnical skills, encompassing the full spectrum of clinical practice including domains such as preoperative evaluation and decision-making. Simulation-based experiences appear to enable and facilitate more rapid and efficient operating room airway management. However, there exist limitation and challenges regarding simulation airway management training for anesthesiologists. The overall evidence for effectiveness of simulation-based methods is evolving to identify the most effective implementation strategies, which include consideration of learner level, instructional design, content specific factors, educator skills, and organizational efficiency. Lessons from aviation, space, and military domains have informed current best practices in healthcare simulation training.[26] Gaps in the knowledge of optimal implementation remain, both in anesthesiology, airway management, and other domains.[5] One critically important factor is the significant difference between simulated and real clinical conditions. First, simulators and simulated airways are designed to represent human anatomy and physiology to the greatest extent possible. Technical limitations, however, constrain the realistic representation of

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many key clinical elements such as texture, mobility, and compliance of upper airway anatomical structures as well as secretions, temperature, and other factors. Limitation of "realism" factors, also referred to as "fidelity," may result in a limited ability to represent and allow practice, development, and assessment of skills (eg, difficult mask ventilation or application of cricoid pressure).[27] Simulators do not always mimic the anatomy of the patients and do not guarantee the evaluation of new airway devices such as SGD.[28–30] Published reports guide the design of educational strategies that target the most effective applications of simulation-based training techniques. Second, both environmental and psychological fidelity (including emotional and psychological components of anesthesiology practice, such as stress) and interpersonal team relationships may be difficult to replicate in simulated environments. The most advanced and technically sophisticated simulators do not guarantee replication of true reality in all domains: environmental, psychological, cognitive, physiological, or anatomic. Limited realism may be especially evident during simulated emergency situations. While lack of realism is often perceived as a limitation by learners and educators alike, it is simply a characteristic of SBME that can be managed and is often leveraged as an advantage for effective educational outcomes. It has been shown that critical factors for simulation-based crisis management training include environmental fidelity and deliberate practice.[10,31]

Instructional Skills

The most effective mitigation strategy to address limitations and challenges is application of optimal evidence-based–simulation-based education methods by instructors and facilitators with knowledge and experience in the specific techniques required for simulation-based training. Instructors of simulation-based training should be familiar with and capable in application of both clinical practice and instructional skills.[32] Learner assessment requires consideration of both formative and summative assessment, familiarity with a range of assessment tools, and common rating rater pitfalls.[33] Instructors who design and use simulation-based techniques for anesthesiologist airway management training should be prepared to evaluate the effectiveness of training, including evaluation of learner technical and nontechnical skills. Faculty skills development focused on simulation education-specific methods may include topics such as debriefing, facilitation, assessment, team training, and scenario design.[34] Scenarios should incorporate elements of realistic clinical experiences and the breadth of clinical practice variation.[35] Simulation educators and facilitators must orient learners to the purpose of simulation training, including orientation to any apparent limitations of simulation-based training or fidelity such as lack of upper airway secretions. Scenario-based simulation integrates debriefing as a key component of instructional design. Instructor scenario facilitation and post-scenario debriefing skills are essential to ensure that educational objectives are met.[7,36,37]

Facilitation and debriefing are instructional skills for interactive experiential learning; they differ in several ways from traditional educational skills utilized in didactic or bedside clinical training. Instructors experienced in simulation-based airway management training and validated curriculum design are indispensable in optimizing the benefits of simulation training for airway management, especially for complex crisis management.

Conclusion

Simulation techniques can effectively improve training of airway management technical and nontechnical skills for anesthesiologists, including basic technical skills, difficult airway management, and crisis management. A structured competency-based transition from simulation to clinical supervision enables individualized pathways, dependent on the level of learner, and benchmark-based assessment. Training paradigms incorporating increasingly complex and realistic simulation experiences and formative assessment represent an evidence-based deliberate practice and mastery learning approach to instructional design.[28,32] Simulation and clinical training are complementary and should be designed as a continuum, incorporating both sequential and parallel training experiences, based on the level of learner and demonstrated competencies. Physical and situational limitations of simulation-based training preclude consideration of simulation as a single training method for airway management competency.[38] Purposefully integrated and complementary blended simulation and clinical airway training offers training and results—the whole of which is greater than the sum of both parts.

Acknowledgements

Financial support for this study was provided by the authors' institutions and departments.

Abbreviations

ASA: American Society of Anesthesiologists

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Financial Disclosures: None.

Conflicts of Interest: None.

Author Contributions: NK contributed to study implementation and manuscript preparation. BWB contributed to the study design and manuscript preparation. Both authors discussed the results and approved the final manuscript.

Abstract: In clinical practice, failure of proper airway management can lead to significant patient morbidity and mortality. Difficult airway management comprises a fundamental skill set for anesthesiologists and has long been recognized as one of the most challenging skills. Simulation-based training is an essential technique to establish and maintain technical and nontechnical skills for airway management. We review the evidence-based utility of simulation-based training for anesthesiologists to accquire technical and nontechnical airway mangement skills. Limitations and challenges of simulation training for airway management and the key role of instructional skills mandate thoughtful and well-designed programs of simulation-based training to assure optimal educational outcomes. Simulation and clinical training should be developed as complementary techniques in an integrated parallel instructional design paradigm to ensure effective development of technical and nontechnical airway management skill for anesthesiologists. Evidence-based educational outcomes favoring simulation-based airway training are highlighted.

Key words: airway management; simulation; anesthesiology; guideline; education