Narrative Review

Simulation in airway management teaching and training

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ABSTRACT

There is a gradual shift in training and teaching methods in the medical field. We are slowly moving from the traditional model and adopting active learning methods like simulation-based training. Airway management is an essential clinical skill for any anaesthesiologist, and a trained anaesthesiologist must perform quick and definitive airway management using various techniques. Airway simulations have been used for the past few decades. It ensures active involvement, upgrading the trainees' airway management knowledge and skills, including basic airway skills, invasive procedures, and difficult clinical scenarios. Trainees also learn non-technical skills such as communication, teamwork, and coordination. A wide range of airway simulators are available. However, texture surface characteristics vary from one type to another. The simulation-based airway management training requires availability, understanding, faculty development, and a structured curriculum for effective delivery. This article explored the available evidence on simulation-based airway management teaching and training.

Key words: Airway, non-technical, simulation, skills, technical, training

INTRODUCTION

Airway management is an essential clinical skill for any anaesthesiologist. The inability to ventilate lungs is associated with severe complications, including mortality. An anaesthesiologist should be able to perform quick and definitive airway management using various techniques during the crisis. Different evidence-based practice guidelines for airway management have been published, providing recommendations regarding safe airway management.[1-3] Though all these guidelines may slightly differ in approaches, they emphasise anticipation of difficult airways, maintaining oxygenation, timely use of various airway adjuncts, using supraglottic airway devices as rescue or definitive measures, surgical airways for complete ventilation failure, effective communication, and coordinated teamwork.

Sustainable airway management training for both normal and challenging airways is essential from the early stage of training. Traditional airway training methods include bedside training on patients under supervision and non-simulation-based training such as classroom lectures, video demonstrations, case discussions, and problem-based learning. However, it might not be enough as an unanticipated difficult airway is rare. Thus, a need for a change in teaching methods has resulted in an innovative training curriculum, which emphasises the importance of proficiency in clinical skills by trainees rather than only theoretical knowledge. Simulation-based medical training (SBMT) is an artificial representation of a clinical scenario using simulation aids to achieve

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experiential learning. Although SBMT is a relatively new concept, simulation has been used for a long time in other high-risk professions, such as aviation.[4-6] SBMT allows the acquisition of clinical skills through repeated practice with simulation tools as an alternative to real patients. A trainee can learn and make mistakes without fearing harming the patient.

This review article aims to highlight the importance and provide current evidence of the use of simulation for airway management training.

METHODS

We searched the PubMed and Google Scholar databases for relevant articles published between November 2013 and 2023 using the keywords "Airway," "Airway management," "Simulation," "training," "training," and "education". We included observational studies and randomised and non-randomised clinical trials, which mentioned simulation-based training/training/education for airway management. After applying a suitable filter, the initial search yielded 232 publications. Duplicate articles, articles in non-English language, and articles without electronic full text were excluded. The randomised and non-randomised clinical trials and observational studies published as letters to the editor, brief communication, or clinical communication were also excluded. After reading the full text, 36 relevant studies were included in this review.[7-42]

DISCUSSION

With a limited number of difficult airway cases and safety concerns, trainees often get limited opportunities to learn airway skills, especially advanced airway techniques. Expanding routine use of supraglottic airway devices may reduce the practice of various basic airway skills, including face mask ventilation and laryngoscopy. Besides this, the teaching of airway skills is highly variable.[7,43] The progressive increase in newer and more advanced airway devices and techniques requires updated training and skills in airway management.[8,9]

Simulation-based airway management has been adopted in the past few years to fill these potential gaps in airway management skills. It has shown validity and superiority over non-simulation-based teaching. Simulation training provides a distraction-free and risk-free environment that improves learners' satisfaction, crisis management skills, and behaviours compared with no intervention and non-simulation education, for example, video, lectures, and self-study [Table 1]. It ensures abundant opportunities and active participation of the trainees, thus enhancing the knowledge in technical and non-technical skills, decreasing errors, and improving patients' safety.[10,44,45]

A trainee can practise basic and advanced airway skills, difficult airway management strategies, and crisis management skills. Both technical and non-technical skills can be learned through simulation teaching [Table 2].

***Technical skills*:** Technical skills range from basic airway skills such as bag and mask ventilation, use of oral or nasal airway, and use of airway adjuncts including bougie or stylet to advanced airway skills such as cricothyroidotomy, flexible fibreoptic intubation, and so on.[11-14] A recent study done on a cohort of anaesthesiology and otolaryngology residents reported no familiarity or feeling uncomfortable with cricothyroidotomy (90%), flexible fibreoptic intubation (88%), and tracheostomy (87%). Even for basic airway skills such as oral airway placement, nasal airway placement, mask ventilation, and

Table 1: Strength and limitations of simulation-based airway management training

Strength	Limitation
• Allow repeated practice	• Reality or Fidelity of simulator
• Hands-on invasive procedure	• Cost
• Creation of rare clinical situation	• Need Instructors
• Use of airway device	
• Distraction-free	
• Risk-free for patient	
• Team co-ordination	
• Feedback and debriefing	

Table 2: Technical and non-technical airway management skills

Technical skill	**Non-technical skill**
Basic	• Communication
• Bag and mask ventilation	• Coordination
• Oropharyngeal/nasal airway insertion	• Collaboration
• Use of stylet/bougie	• Teamwork
• Supraglottic airway device Insertion	• Leadership
• Laryngoscopy	
• Endotracheal Intubation	
Advanced	
• Cricothyroidotomy	
• Fibreoptic intubation	
• Lung isolation techniques	
• Airway Ultrasound	
• Robotic intubation	

laryngeal mask airway placement, 7–23% of residents had no familiarity or were not comfortable. Simulation airway training led to a significant decrease (55%, $P < 0.001$) in the mean number of residents reporting no familiarity/not comfortable with various basic airway skills.[15]

Invasive airway access is a technique acquired for "complete ventilation failure" situations. Surgical or percutaneous cricothyroidotomy can be performed during airway crises because it is quick and safe. The choice for a cricothyroidotomy procedure depends on the situation's urgency, operator skill, insertion site condition in the neck, and kit availability. The use of the scalpel, bougie, tube technique for surgical cricothyrodotomy is a simple and feasible (all resources would be available almost at hand, at all locations). Also, the steps are easy to remember / retain by practice. Various commercial cricothyroidotomy sets are available, which vary in size and insertion techniques. Therefore, anaesthesiologists must know the strengths and weaknesses of each technique and available kit. Proper and repeated training is required to reduce morbidity and mortality associated with invasive airway techniques. Not only trainee anaesthesiologists but even senior anaesthesiologists can be trained for invasive airway access using airway simulators.[13,16-19,46]

Reliable placement of lung isolation devices is crucial for anaesthesiologists practising thoracic anaesthesia. However, the use of a fibreoptic bronchoscope does not guarantee zero malposition. A study done on anaesthesiologists who did not regularly perform thoracic anaesthesia showed that the incidence of lung isolation device malposition was 39% despite fibreoptic bronchoscopy use.[14,20-22] An anaesthesiologist must know tracheobronchial anatomy to reliably position double-lumen tubes and bronchial blockers. A group at the University of Toronto developed an interactive online bronchoscopy simulator. This simulator is available online at www.thoracicanesthesia.com. Low-fidelity simulators and three-dimensional printing have been used as teaching tools to reproduce a normal and an abnormal tracheobronchial tree. Despite compromised fidelity, the simulation improves the quality of the clinical experience.[23,47,48]

***Non-technical airway skill*:** Inter-professional effective communication and team coordination are the mainstays for airway management. The 4th National Audit Project of The Royal College of Anaesthetists and the Difficult Airway Society identified persistent practice gaps such as delayed recognition of critical situations, inadequately trained staff, poor communication, and team collaboration.[49] Often, several anaesthesiologists with different experiences work together during a crisis. The crisis needs rapid decision-making in response to changing clinical conditions of patients. Lack of coordination, communication skills, and leadership during airway management may lead to adverse effects. The five core competencies are: 1. Roles and responsibilities, 2. Ethical practice, 3. Conflict resolution, 4. Communication, and 5. Collaboration and teamwork. Simulation-based training helps inter-professional learning; thus, teamwork improves the quality of patient care.[24,25,50]

***Other benefits*:** Paediatric and obstetric patients need special anatomical and physiological considerations during airway management. These populations represent a greater risk of hypoxia and airway complications than the general population. Thus, the airway algorithms slightly differ. Simulation-based training would provide risk-free hands-on to all trainees.[26-28,51]

Point-of-care ultrasound and robotic sciences have revolutionised various aspects of peri-operative care, including airway management. Simulation-based training for these newer technologies would help young anaesthesiologists and senior anaesthesiologists.[29] Various uncommon clinical situations, such as an airway fire, can be simulated during simulation-based airway training educational programmes. Trainees can benefit from drills with debriefing and group discussion.[30-32]

Besides training purposes, these simulators are now widely used for training purposes and as an innovative way to answer many research questions related to airway management; for example, the effect of an aerosol box during airway management reduces healthcare practitioner exposure, and so on.[33-37]

***Skill assessment*:** A wide range of simulators are available. It can range from handmade tracheo-bronchial trees to high-fidelity manikin and virtual reality with a feedback system. Though they defer in fidelity, they allow the acquisition of skills. Generally, technical skills can be improved with low-fidelity simulators. The aim of imparting specialised skills to learners is to give them good knowledge of airway anatomy, airway

devices, and their indications. High-fidelity simulators promote better team coordination with a realistic environment to re-create usual work conditions, which is helpful for both active and passive learners.[4,38-40] The benefit level after simulation training can be judged by a training evaluation model proposed by Donald Kirkpatrick. The Kirkpatrick model is globally recognised to assess training methods and rate them against four levels of criteria: reaction, learning, behaviour, and results [Figure 1]. Simulation makes it possible to reach levels 1 to 3.[52]

Challenges of Simulation-based Airway Management Training: Simulators provide a safe and reproducible environment to practise airway management skills through repetitive practice, but simulation training has limitations [Table 1]. The dissimilarities between the simulator (plastic or silicon models) and the live tissues of patients in texture, surface characteristics, and the lack of dynamic interaction with the model during task performance limit a few fine motor skills.[39-41] Low-fidelity airway simulators such as Laerdal Airway Management, Laerdal Little Junior QCPR, and Ambu Airway Management Trainer are often used for basic airway management skill training, while high-fidelity airway simulators such as SimMan 3G and Emergency Resuscitation Simulation Systems by SmartMan, ORSIM, provide realistic training environments and closely mimic real-life scenarios. Both simulators are effective tools for practising airway management skills. Selection between a low-fidelity and high-fidelity airway simulator depends on learning objectives, budget availability, and portability. Even in low-resource settings, various indigenous simulators, such as 3D-printed bronchoscopy simulators, are comparable to commercially available ones. They can be an inexpensive alternative for teaching airway skills.[22,23,48]

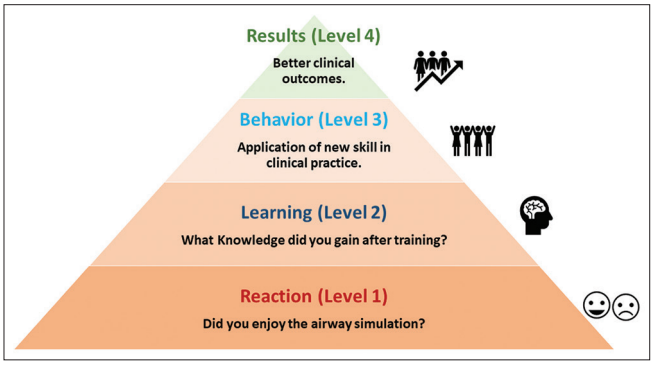

Figure 1: Kirkpatrick Model

For effective simulation-based airway management training, high-fidelity simulators and instructors with good experience in airway management simulation training are necessary. Instructors must adapt to the simulation teaching curriculum and familiarise themselves with core competencies. Faculty development programmes in airway simulation enhance the skills and knowledge of educators. They learn essential skills such as preparing for a simulation, pre-briefing, running a clinical scenario, and conducting a debriefing. It will also support the effective simulation-based educational methodology with an evidence-based framework and deliver simulation programmes.[52,53]

A specific curriculum for simulation-based training is essential. However, a few questions remain unanswered, such as the minimum number of successful procedures required during simulation training and the frequency of training for different trainee levels.[42] Recently, a multi-national Utstein Simulation Study Group successfully developed an agenda to integrate simulation-based medical training into anaesthesiology to identify the learning objectives and evaluation methods. The proposed six-step approach seems to be valuable and valid. Their results may facilitate simulation-based training for many anaesthesia-related core competencies.[53]

CONCLUSION

Management of the airway is a necessity not only for an anaesthesiologist but also for emergency physicians and intensivists. Simulation-based training has an essential role in effective airway management training. It improves both technical and non-technical skills in airway management. Simulation-based airway management training needs experienced instructors and a robust curriculum design to optimise the benefits, especially for complex crisis clinical scenarios. Always consider the limitations of simulation-based training while assessing the learner's skill.

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