Optimizing education in difficult airway management: meeting the challenge

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Purpose of review
The last 2 decades have seen a vast change in the science and technology of airway management. As a result, there is an increasing need to equip anesthesiologists with the new knowledge and skills for the safe management of a difficult airway.

Recent findings
In addition to knowledge and expertise, human factors and nontechnical skills (NTS), including situational awareness, communication and teamwork, play an important role during difficult airway management and contribute to the outcome. Didactic sessions are useful to impart knowledge. Self-learning, interactive discussions, simulation and debriefing are important tools for teaching and training in difficult airway management. Manikin training and simulation enable development of technical as well as NTS without subjecting patients to risk and allow multiple training sessions of relatively uncommon scenarios. Guidelines are useful teaching tools, whereas cognitive tools such as the Vortex approach may be useful during a difficult airway.

Summary
There is need for research on difficult airway management and optimized training methods. Research is also required to determine the barriers to adoption of guidelines and strategies to ensure widespread dissemination and implementation of guidelines and best practices for difficult airway management.

Keywords
airway education, airway simulation, difficult airway management, difficult airway training, optimizing education

INTRODUCTION
A difficult airway is defined as a situation when a conventionally trained anesthesiologist experiences difficulty with facemask ventilation, tracheal intubation or both [1]. Though only 0.5–2.5% of intubation attempts are difficult [2], it is leading cause of anesthetic morbidity and mortality [3], and a failed intubation results in a perioperative crisis [4]. Thus, optimizing education in difficult airway management, with the goal of improving knowledge and skills, is essential to promote safe airway management. The last 2 decades have witnessed a sea of change in the availability of equipment, necessitating an increased focus on training in a wide spectrum of airway management techniques [5].

An unanticipated difficult airway tests both the technical and nontechnical skills (NTS) of the provider, during a potentially life threatening clinical situation [6]. However, most intubations are not challenging in experienced hands, making experience of handling difficult airway limited. Thus, with limited opportunities to obtain hands on experience with patients having a difficult airway, simulated difficult airway scenarios using manikins, videos, advanced training software and so on must be included in training, to optimize both technical and nontechnical airway skills. Although these teaching methods are useful when used appropriately, they do not substitute experience with real patients, under the supervision of experts in difficult airway management. In addition, knowledge and skills acquired may be lost or diminish over time if not put to practice regularly. Hence, training should be ongoing, especially for rare situations like the need for surgical airway access. This article will review various challenges faced and techniques to optimize education in difficult airway management.
REQUIREMENTS FOR TRAINING IN DIFFICULT AIRWAY MANAGEMENT

Education in difficult airway management should involve training in managing both anticipated and unanticipated difficult airway situations. Unlike in an anticipated difficult airway where there is time for prior planning, preparation and expert help can be made available, during an unanticipated difficult airway, time, preparedness and expertise may be inadequate to handle the situation. During such crisis situations, one may be overwhelmed by more information than one can process and this may lead to significant cognitive dysfunction which can impair decision making. There can be error of judgment, complacency and fixation errors that can influence outcome during these situations [6]. Thus, in addition to imparting knowledge and technical skills, training in NTS, like effective team work, communication, shared understanding of roles, taking leadership roles should be included which have been detailed in Table 1.

CHALLENGES IN DIFFICULT AIRWAY MANAGEMENT AND POSSIBLE SOLUTIONS

Several challenges may be faced while working toward optimizing education in difficult airway management, with some possible solutions which have been detailed in Table 2. Appointing an ‘airway leader/champion’ in the department may be useful. This individual should be responsible for planning educational activities in airway management and finding solutions to the various challenges faced.

VARIOUS METHODS OF IMPARTING EDUCATION IN DIFFICULT AIRWAY MANAGEMENT

Knowledge

Didactic teaching

Didactic teaching is a fundamental tool for novices, encompassing classroom-based teaching. It is the foundation or starting point for basic teaching in the subject, in which the overall goal is knowledge. The trainer usually functions as an authoritative figure, a guide and a resource person for students, whereas the trainee usually plays a comparatively passive role. For effective communication, the number of participants should be small, and there should be a two-way communication between expert and trainee. Use of videos, books, pictures should be encouraged. Use of mnemonics, like the LIVES (Laryngoscope, Intubation tube, Ventilation, End-tidal CO₂ monitor, SaO₂ monitor) mnemonic for safe insertion of the tracheal tube [7] are effective strategies for remembering important steps and providing a structured process to follow.

Interactive discussions

Prediction of difficulty in airway management is not completely reliable [8]. Airway management is safest when potential problems are identified before its occurrence and a planned management strategy, aimed at reducing risk, discussed with the team [9]. Difficult airway cases may be presented and discussed focusing on developing critical decision-making processes. Using problem-based learning discussions facilitates interactive teaching and better knowledge retention.

Open learning

In this method, the trainees can learn on their own, in an unstructured manner, on topics of their interest. Essentially it fulfills the ‘needs of the learner as perceived by the learner’. This may involve the use of text, images, audio/videos resources and internet resources and may also include distance education.

Audio visual aids

Recorded and live videos showing different airway procedures and instrument use during difficult
Interactive video sessions with brief discussion at the end are useful. The advantage of recorded videos is that they can be stored and replayed. As they are edited, they clearly demonstrate the steps, helping in more superior knowledge retention than lectures, books and discussions. A recent study ran-randomized medical students to one of the four versions, to improve the effectiveness of enhanced podcasts for knowledge retention and clinical skill acquisition (first) control: narrated presentation; (second) modeling: narration with video demonstration of skills; (third) mental practice: narrated presentation with guided mental practice; (fourth) combined: modeling and mental practice. Following this, they were subjected to a manikin-based simulated airway crisis. The combination of mental practice and modeling led to better performances.

WhatsApp and mobile phone applications
Smart phones with various applications like (‘WhatsApp’ Inc., Menlo Park, California USA) have changed the methods of communication. ‘WhatsApp’ can be used to provide continuous knowledge and suggestions to all group members. It is a low-cost and fast technology [11] that offers an opportunity to facilitate effective communications and enhance learning. Group members can share their experiences on difficult airway management.

Technical skills
Actual patients
There is limited opportunity for learning difficult airway management on patients and teaching opportunities are limited especially during a crisis situation. Videolaryngoscopes associated with multiperson visualization could enhance learning during airway management. Increasing learning experiences with daily practice in different laryngoscopes is needed, so as to use them effectively in difficult airway setting [12].

Manikins and models
Difficult airway skill acquisition and device orientation can be accomplished by using manikins having difficult airway configurations. With the help of different level of difficulty in manikins, it is possible to train novices without exposing patients to risk. Manikin training is considered as equivalent to cadaveric training in airway management [13]. Even the most advanced simulation manikins are not able to provide the same finer details and feel of the human airway anatomy and should therefore be selected cautiously, depending on the type of airway securing procedure they are required for [14,15**]. There can be variation among manikins from the same manufacturer, and they have poor laryngeal anatomy, rigid tissues and poor face mask ventilation [16–19].
A recent study [20] evaluated the anatomic fidelity of commercially available manikins by experienced otolaryngologists using rigid and flexible endoscopy, using a 5-point scale for the following: nasal cavity, nasopharynx, oral cavity, oropharynx, larynx, trachea, esophagus, and neck. There was variation in the anatomic fidelity in a range of manikins. These scores may be used to select manikins having the best anatomic fidelity for specific educational purposes, and they may help in contributing to recommendations to improve manikin design in future. A study comparing three approaches of teaching nonmedical personnel supraglottic airway insertion in a manikin, showed that the best results were obtained after practical training, followed by video presentation and finally lectures, irrespective of the airway device used [21].

**Cadavers and animal models**

Cadaver-based and animal model training is the closest to working on real patients. However, there is limited access to this form of training due to cost and availability. A recent study among residents for performing cricothyrotomy [22] found that cadaver-based training provides superior landmark and tissue fidelity compared with simulation training and is especially for training in infrequent procedures.

**Nontechnical skills**

**Simulation training**

Human factors issues contributed to adverse outcomes in 40% of the instances reported to the fourth National Audit Project [9]. Simulation involves...
recreating or imitating part of some clinical scenario for purpose of training or evaluation [23]. Simulation scenarios can be used for orientation to new procedures, exposure to uncommon clinical scenarios and assessment of knowledge. For detailed discussion on simulation of airway management, please refer to Dr Biro’s (pp. 743–747) article of this issue [24].

**Role play**

Role play can be done with actors who can simulate a crisis situation during difficult airway management. This is useful to train in NTS like effective team work, communication, taking leadership roles and other soft skills required during a crisis.

**Debriefing**

Debriefing can be done following a real airway crisis or a simulated crisis using manikin simulators or actors. A usual simulation experience has three components: the initial briefing, the actual simulation experience and the debriefing. During debriefing, an experienced person discusses the trainee’s experience during the crisis situation. It allows trainee to understand their decision-making processes and change their clinical practice for better patient outcomes. It is an interactive educational tool that helps build confidence, improve clinical knowledge through practice and enhance team performance.

**Training for surgical airway control**

Transtracheal oxygenation and cricothyrotomy are the final options in airway management algorithms. These techniques, although rarely performed by physicians, are of vital importance when needed. Retention of skills is poor, lasting only a few months training courses; hence, use of manikins and simulation can be considered the standard of learning [25]. Ultrasonography is used more recently in airway management for identification of surgical airway landmarks for performing emergency cricothyroidotomy [26]. Airway structures can be identified before induction of anesthesia, so that emergency surgical airway if required, is performed with the knowledge of the underlying airway anatomy. Studies suggest that anesthesiologists are often unable to accurately locate the cricothyroid membrane, particularly in obese and female patients [27]. A survey conducted to determine the methods used to teach surgical airway management to the residents in the United States, showed that the majority of anesthesiology training programs, provide some form of skill-based instruction for their residents [28].

**EVALUATION OF DIFFICULT AIRWAY MANAGEMENT TRAINING**

Optimal methods of evaluation of difficult airway management training have not yet been developed, and the frequency of training needed to maintain most skills has not been clearly defined. Due to this lack of standardization, the actual level of competence following training is difficult to assess. Kirkpatrick and Kirkpatrick [29] has described a ‘four level’ model of training program evaluation. Level 1 describes the ‘reaction’ from the participants, levels 2 and 3 describe ‘learning’ and ‘behavioural change’ and level 4 describes any changes resultant on the behavioral changes, for example patient outcomes. He defined learning as the extent to which trainees attitudes change, increase knowledge or improve skill as a result of attending an educational program. All training program should evaluate all the four points to optimize training.

For assessment of NTS, there are tools like anesthetists’ NTS (ANTS) scale and more recently the behaviorally anchored rating scale (BARS). A recent study [30] comparing the reliability and validity of the two scales showed that the overall reliability estimates were better for the BARS scores than the ANTS scores.

**ROLE OF GUIDELINES, ALGORITHMS AND COGNITIVE AIDS IN THE TRAINING IN DIFFICULT AIRWAY MANAGEMENT**

Several evidence-based guidelines are available for difficult airway management [1,6,31–35]. The aim of the guidelines is to provide a structured response to a potentially life-threatening clinical problem. Algorithms are intended as teaching and learning tools and are not specifically designed to be used as prompts during an airway crisis [31]. Guidelines and standard algorithms are useful for didactic teaching, case discussions and debriefing after a critical incident. On the other hand, cognitive aids, such as the ‘Vortex Approach’ [36] is a complementary resource, designed to facilitate implementation of the management guidelines and improve the performance of clinical teams during an airway emergency.

**DISSEMINATION OF EDUCATION AND IMPLEMENTATION OF GUIDELINES IN DIFFICULT AIRWAY MANAGEMENT**

Guidelines and protocols for difficult airway management, as well as cognitive aids to airway management emergencies must be widely disseminated, adopted and practiced to reduce morbidity and mortality. However, adoption of recommendations
in guidelines is variable. It is essential to audit the extent of compliance to guidelines to determine strategies for more effective dissemination, and to overcome barriers in implementation. For example, the Difficult Airway Society’s guidelines [31] recommend that videolaryngoscopes should be immediately available at all times and all anesthetists should be skilled in their use. However, in a recent survey on the use of videolaryngoscopy in the national health services in the United Kingdom [37**, it was observed that videolaryngoscopy was available in 91% of operating theatres, 50% of ICUs and obstetric theatres, with lower availability in emergency departments, pediatric anesthesia and independent sector hospitals. Device selection was rarely based on published literature or formal trials. Penetration of videolaryngoscopy was highly variable, with less than one-third reporting widespread use. There was also a wide variation in device, methods of introduction and clinical usage.

**FUTURE DIRECTIONS IN TRAINING IN DIFFICULT AIRWAY MANAGEMENT**

Airway management will continue to evolve and training will undoubtedly be required to understand newer technology and acquire technical skills. An increased emphasis in training to optimize oxygenation during difficult airway management using techniques such as noninvasive positive pressure ventilation for preoxygenation [38], apnoeic oxygenation [39] and high-flow oxygen by nasal cannula [40] are required. There will be an increased focus on ‘exit strategies’ like rapid reversal of neuromuscular blockade with drugs such as sugammadex that can reduce the ‘at risk’ duration. Human research into the difficult airway is important, yet difficult and may raise certain ethical concerns [41]. It is essential that consensus guidelines on ethical research on clinically relevant problems are developed [42]. Research into implementation barriers and human factors during difficult airway management will be required to determine the best approach to teaching and training, and to develop methods that will lead to universal adoption of strategies that will make airway management even safer.

**CONCLUSION**

Teaching and training in difficult airway management must encompass development of technical as well as NTS. Given the limited opportunities for real-life training and experience in difficult airway management, technical skills can be developed on manikins and cadavers, whereas simulation helps development of NTS. Further research into implementation barriers and human factors during difficult airway management will be required to determine the best approach to education on airway management.

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**Conflicts of interest**

There are no conflicts of interest.

**REFERENCES AND RECOMMENDED READING**

Papers of particular interest, published within the annual period of review, have been highlighted as:
- of special interest
- ± of outstanding interest

11. Enhanced podcasts increase learning, but evidence is lacking on how they should be designed to optimize their effectiveness. This is the first randomized control trial that shows that effectiveness of enhanced podcasts for knowledge retention and clinical skill acquisition is increased with either mental practice or modeling.

This is the first study was to investigate the accuracy of modeling and reproduction of human anatomical dimensions by manikins by comparing radiographic upper airway measurements of models with humans which showed that all of the examined manikins did not replicate human anatomy. It questioned their widespread use as a replacement for in-vivo trials in the field of airway management.
This is the first study that evaluates the anatomic fidelity of several commercially manikin on a 5-point scale by experienced otolaryngologists using rigid and flexible endoscopy. Ratings by survey participants demonstrated variation in the anatomic fidelity of the aerodigestive tract in a range of manikins. Differences in scores may allow instructors to select manikins with the best anatomic fidelity for specific educational purposes, and they may contribute to recommendations to improve future manikin design.
A randomized controlled trial comparing the assessment of three approaches of teaching combat soldiers the handling of supraglottic airways for trauma airway management, showing that practical training is the superior instruction method compared with theoretical lecture and presentation of an instruction video.
A pilot study to assess whether there is a significant difference in fidelity and educational experience of cadaver-based training compared with simulation training and may be a valuable addition to residency training for certain low-frequency procedures.
24. Dr. Bro’s article of this issue (page 000–000).
This is the first study comparing a new tool for assessing the nontechnical skills (NTS) of anesthesia providers, the behaviorally anchored rating scale (BARS) and comparing its scores with those of an established NTS tool, the anesthesiists’ NTS (ANTS) scale. Overall, reliability estimates were better for the BARS scores than the ANTS scores. The BARS tool can be an alternative to the ANTS scale for the formative assessment of NTS of anesthesia providers.
The Vortex contains the first cognitive tool which has been proposed for use during difficult airway management and may be effective in reducing implementation errors in emergency airway management. Experimental evidence is required to establish this.
The Difficult Airway Society’s 2015 guidelines recommend that videolaryngoscopes should be immediately available at all times and that all anaesthetists should be trained and skilled in their use. This is the first survey looking at examine availability, use and attitudes to videolaryngoscopy. There is marked variation in device, methods of introduction, usage and clinical adoption. Most hospitals need to change practice to comply with current guidelines.
41. Cook TM, Duggan LV, Kristensen MS. In search of consensus on ethics in airway research. Anaesthesia 2017. [Epub ahead of print]