

## Airway management education: an update. It is high time to realize professional airway training as an art

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**Summary :** Airway training is one of the key element residents need to master during their anesthesiology teaching program. Airway-related disasters during this training might be prevented by the supervision of highly skilled airway experts as teachers. In the present day, a multimodal blended training approach helps in the planning for airway management teaching including both technical and non-technical skills. "Difficult Airway Response Team", advanced airway management rotation, case presentations to learn presenting and augmenting about clinical approaches, formalized airway training certificate based on defined competences, hands-on practices, virtual reality airway simulators, high-fidelity full-scale simulators, fresh cadavers, specific "Train the Airway Trainer Courses" resulting in certified "Airway Teachers", and ultimate deliberate practice on models and patients are cornerstones of teaching and learning airway management. Even though the working hours of the residents in the operating room are reduced due to legislation, it is still possible to provide high quality anesthesiology training to manage the airway by creating the triangle of airway management, quality improvement and patient safety. Ultimately the provision of higher quality airway training needs to be translated into improved patient safety embedded in high end healthcare organizations.

**Key words:** airway management; education; training

### THE SIGNIFICANCE AND NECESSITY OF AIRWAY TRAINING

Anesthesia training is a comprehensive training that begins with preoperative evaluation providing safe anesthesia and includes postoperative management. The primary goal of airway training is to establish a patent airway safe and to decrease the incidence of 'airway-related complications'. That is possible when the anesthesiology resident receives sufficient theoretical achievements and practical training by mastering different airway devices, airway management techniques based on related guidelines applying technical and non-technical skills. European Resuscitation Council guidelines include recommendations for education and implementation of resuscitation (1). The practice

guidelines for the management of difficult airway should include the recommendations for airway education in a similar way. Thus the teaching strategies can be developed.

The 4<sup>th</sup> National Audit Project (NAP4) reported major complications related to airway management during anaesthesia, between September 2008 and August 2009 in the UK (2). In this analysis in more than three-quarters of anaesthesia events, intrinsic patient features contributed to the airway event. Training and judgement were the most common extrinsic contributory factors.

In order to prevent airway-related catastrophes, airway training should be the key element of anaesthesia practice during anesthesiology residency. Today, it has been already admitted that learning is a life-long process, but the main factor putting pressure on anesthesiologists is the question how effective airway training can be achieved (3). Difficult airway may be considered as the most difficult situation that an anesthesiologist can come across because it may be the end of the film instead of a beginning. The methods applied for management of difficult airway represents the heart of anesthesiology experience. Therefore, anesthesiologists are often regarded as airway experts by other branches of medical care (4).

Furthermore individuals to receive airway training should have capacity for training and be motivated to learn. Airway management training has long been implemented as a six-step process prescribed in the 6-step framework for teaching procedural skills in medicine by Sawyer et al. (5). Those steps are: Learn, See, Practice, Prove, Do, and

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Maintain. Simulation-based training is an unrivaled method for the “*Practice*” and “*Prove*” steps of this instruction model.

### History

One of the first evaluation regarding adverse outcomes of anesthesia was presented in 1985 by investigating the closed claims of American Society of Anesthesiologists (ASA), and these catastrophes for the patients were regarded as ‘acceptable’ or ‘sub-standard’ practices and though to be prevented through more elaborate monitoring (6). The publication of the article ‘Respiratory Events’ by Caplan, Posner and colleagues in 1990 was a turning moment in anesthesiology (7). Respiratory events were indicated to be responsible for death or brain damage in 85% of 500 cases, which comprised 34% of all the reported cases. In other words, the retrospective analysis of ASA closed claims suggested that the problems with airway management were among the main causes of anesthesia-related morbidity and mortality. Afterwards the National Audit Project of United Kingdom (NAP4) concluded that anesthesia-related deaths were again associated with failed or proper performed airway management revealing that the rate of difficult intubation was 6.2% (2). Additionally, the cost of airway disasters was considerably high (8). However, 70% of such disasters might be prevented through appropriate use of standards, evidence-based knowledge and proper trained skills (9). The Association of Anesthetists of Great Britain and Ireland published a handbook entitled ‘Assistance for the Anesthetists’ in 1998 (10). The primary aim was to create an efficient and reliable anesthesiology service while setting basal standards for training the anesthesiology residents.

#### THE CURRENT METHODS FOR AIRWAY MANAGEMENT EDUCATION

The lowest level of the Miller’s Pyramid describes the knowledge of the learner (11). At the next level, the learner performs and manages tasks under supervision. Further up the pyramid, the learner performs and manages what s/he has learned on her/his own. Ultimately at the top of the pyramid, the learner is not a learner any more but becomes an expert. As it is understood also from the pyramid that the level, where knowledge transforms into practice, intersects with simulation. Nevertheless, if the training is not coherently planned, there may be a significant illusion between the thing to be learned and the thing that have been taught. For this reason,

feedback and assessment are a must in training. Learning environment, identification of the aims of the training and assessment are the key components of feedback. Daily practice helps learning, but if training does not continue to a certain extent, it may result in dangerous outcomes. Therefore, training should go on until the trainee reaches the expert-level (12).

The use of fresh cadavers is the safest and most effective method to teach invasive airway skills (13). Simple models are useful for novice practitioners to master basic skills; however, high-fidelity devices are preferable for experienced practitioners to acquire skills required for more advanced airway procedures and to work on more challenging tasks such as invasive procedures learned on obese patients or on distorted necks (14). For this reason, there should be a consistency with the expertise level of the learner and the fidelity of the simulator. Johnson et al. (15) introduced the part task and variable priority training models. These two approaches have been developed by psychologists as solutions for complex situations, i.e. in situations when more than one complex task should be carried out simultaneously. Part task training means getting specific roles or duties in a team and learning how to complete the whole task by decomposing it into multiple task components as well as automatizing them. In this way, the trainees will be able to automatically realize the algorithms when they are alone. In variable priority training, trainees are taught how to coordinate and control attention, and it is all about creating a flexible cognitive cartography as a conductor. In other words, the complex cognitive tasks will no longer be a dark tunnel without a light at the end in this model. Training programs should be designed to involve repeated practices and allocate less time to theory in order to enable trainees to transfer the knowledge and skills they have acquired into practice (16). Part task training focuses on dividing complex tasks into components followed by intensive concentrated training on individual components. Variable priority training focuses on optimal distribution of attention when performing multiple tasks simultaneously with the goal of flexible allocation of attention. High fidelity simulators and simple bench models are used within the scope of simulation-based training. A study compared inexpensive low-fidelity simulators with costly high-fidelity simulators in oral fiber optic intubation training. The study proved that there was no statistically significant difference between low- and high-fidelity models regarding success or duration of tracheal intubation (17).

The high-fidelity full-scale simulators have been observed to increase the cognitive and psychomotor performances in emergency cases (18). With the use of debriefing method, the simulation-based training has become a substantial method for acquiring and testing practical skills. Originally, modern high-fidelity full-scale simulators infrequently found place in high risk scenario trainings for aviation and military sectors, and later started to be employed in health sector. By this way, it also ensures increased patient safety. Now, there are Advanced Airway Skills Laboratories equipped with modern actual size simulators (19). When simulation trainings are supplemented with lectures on the related subject, the success rate of the training increases. Besides, when the simulation-based airway training is designed to cover a combination of different sub-divisions, such as mannequin-based simulation, micro-simulation and partial task training, the success rate of the training potentially increases (Fig. 1). In this way, not only knowledge is converted into kinesthetic power but also muscle memory is gained. To what degree the trainers can apply the knowledge and skills gained in simulation scenario in clinical practice is important for effectiveness of the study. Pre-tests and post-tests are useful for quantitatively measuring the effectiveness of the training.

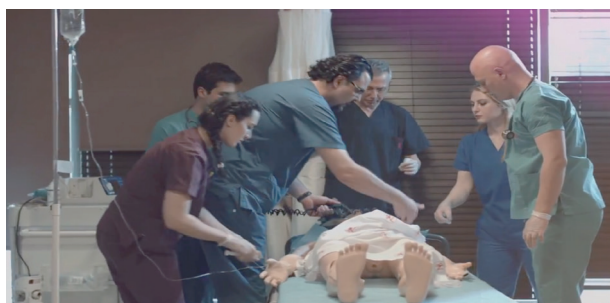


Fig. 1 — The Mannequin-based simulation training for building clinical teams.

According to a survey study conducted in the USA, practice on mannequins is the most frequently used training method (57%) in airway management training, followed by didactic teaching (31%), large animal laboratory or a cadaver workshop (29%), and lastly human patient simulator training (24%) (20). On the other side, practice on cadaveric simulators guided by experts is another common method for airway training (21). They are considered useful for providing realistic invasive airway training. It is obvious that simulation helps providing high quality training; however, Cadavers are often used for cannula or surgical cricothyroidotomy trainings (22). The use of human cadavers and animals in training is a controversial

issue today. Because firstly, trainees wonder whether there is a need for practice on cadavers in presence of such useful simulators; and secondly, they think the fresh frozen cadavers allow the use of only a few devices and old cadavers may not be suitable for use due to scleroma. When it comes to the use of animals, it is true that animals can imitate humans regarding the secretions and bleeding in invasive procedures; however, practitioners must not violate the ethical rules in their experiments. Also, the question of whether the animals will be sacrificed or not after the use of laryngeal mask or intubation comes to the fore as another significant problem in anesthesiology training. Creation of life-like animal training manikins may be an alternative solution to this problem (23).

#### THE PROBLEMS ENCOUNTERED

In the past, the basic airway training composed of 3 steps, via face mask, direct laryngoscopy, and cricothyrotomy. As anesthesia residency is often divided into sub-specialities e.g. pain medicine, intensive care, or health management topics, residents spend unfortunately less and less time in the operating room. Therefore, they do not observe enough patients with difficult airway to get up to expert level. Exposure to cases is a prerequisite to deliberate practice to achieve the expert level our patients deserve. Another down side is the recent change in anesthesiology practice affecting airway management. The increased use of regional anesthesia results in less airway procedures, the extensive use of supraglottic airway devices results in less and less intubations, or the fear that residents do not learn direct laryngoscopy due to the use of video laryngoscopes (24). And finally: The European Working Time Directive limited working hours, the duration of operating-room training has become shorter (25).

The economic pressure to finish the operation list as fast as possible and to squeeze in another case pushed anesthesia staff and faculty members away from protected “time devoted to teaching and training”. Due to busy schedule of the day, there may not be enough time for training.

Even though the working hours of the residents in the operating room are limited, it is still possible to provide high-quality airway management training. If each department approaches the problem by setting specific training standards, problems may be resolved. In a review involving 50 studies, 14 of which addressed airway management methods, simulation-based education was shown to be



associated with low to moderate patient benefit when compared with no intervention and non-simulation instruction (26).

Nevertheless, there are still many residents that become specialist without getting necessary theoretical and practical training and substantially specializing in airway management during residency. The tendency for practical training has been increasing recently. Traditional approach is no longer considered adequate in Europe for basic and advanced airway trainings that should be given during residency. The airway training practiced previously was like training scenarios of a science condensed in daily practice. Airway management training and skill attainments were randomly fitted into the daily routine until recently.

Interestingly, Cormack and Lehane (27) indicated that an anesthesiologist performing 200 tracheal intubation per year come across only 32 grade III difficult intubation cases within 12 years. The incidence of grade III intubation has been found to be 1.3% for every 100 intubation practices performed by the residents. It means that 27% of the residents never face with a grade III case in their first 100 intubation practices.

In a Danish survey, only 17% of 36 anesthesiology residents were reported to be successful in written exam on a Cannot Intubate Cannot Ventilate (CICV) scenario (28). Of all the participants, 97% had difficulty in applying the ASA difficult airway algorithm and 53% did not know how to oxygenate via the cricothyroid membrane. While 75% tried Laryngeal Mask Airway (LMA) ventilation, 26% tried surgical airway. This survey proved that these anesthesiology trainees had inadequate knowledge on oxygenation of the patient via the cricothyroid membrane.

Despite all that, anesthesia trainees are trained in a variety of difficult airway situations during residency, but also provision of routine trainings on surgical techniques by the medical center is also important. Interviewees of 82 anesthesiology residency program directors accredited by the Accreditation Council for Graduate Medical Education (ACGME) in United States, revealed that 72 centers include surgical airway management training in their curriculum (20). Interestingly they describe mannequins as the most frequently used teaching method (57%), large animal laboratories or cadaver workshops were less frequent (29%), but human full scale patient simulator were the least reported teaching method. Another survey concluded that 92% of senior residents had no experience in surgical front of the neck airway

techniques (29).

In the scope of traditional approach, a resident was primarily taught how to ventilate the patient with the face mask, and only when s/he becomes competent with face mask, s/he was schooled in direct laryngoscopy and tracheal intubation. When it came to fiberoptic intubation, it remained as an advanced method, which the resident might be able to perform if s/he was lucky enough to come across towards the end of residency. However, this traditional approach adopted for training of residents is being questioned nowadays.

Trainees other than the practitioner did not really comprehend what was happening because the video camera-integrated systems applied in clinical practice currently were not available. How effective learning can be achieved by reading in a branch that requires so much practice? Anesthesia training is no longer limited with the three key techniques mentioned above. Actually, there is no evidence supporting the step-by-step method and the traditional mentoring model is about to become a thing of the past. Advanced training does not have to be delayed until the later phases of anesthesiology residency. Cole et al. (30) indicated that fiberoptic intubation is as learnable as direct laryngoscopy in the beginning of the residency.

#### WHAT IS NEW IN AIRWAY MANAGEMENT TRAINING?

Self-instruction video training was found to be as effective as face-to-face training in relay and acquisition of basic emergency skills (31). Multimodal training approach is in use today. In this connection, multidisciplinary Difficult Airway Response Teams (DARTs) are integrated into hospitals through training of medical experts from different branches to improve emergency response process (32,33). Annual cost of a DART may increase up to 543.633 USD (34). In some medical centers, airway response teams may cooperate with trauma teams for trainings in order to enhance patient safety (35). The current anesthesiology training in Sweden involves presentations, publications, modules, courses and certification, e-learning and exams resulting in specialization. However, there are some institutions integrating practical applications, such as ILMA Monday or Fiberoptic Friday in the training process. In this way, the residents find the chance to practice their airway skills on specific days on elective patients without difficult airway. An American model published by Dunn et al. (36) in 2004 addressed advanced airway rotation. Here, the 2-month advanced airway rotation program was

prepared by a group of expert trainers. The first month of the program could be completed between the 6<sup>th</sup> month and 1<sup>st</sup> year of residency and the 2<sup>nd</sup> month of the program could be integrated into the 2<sup>nd</sup> year of residency. Moreover, it has been affirmed that advanced airway rotations are frequently recommended in Canada (37). There are several on-going researches investigating detailed and ideal airway management program. A survey study in USA questioned 132 medical centers on whether they practiced difficult airway rotations or not, and only 79 (60%) of them responded (38). Twenty six centers forming 33% of the participants held difficult airway programs. While 32% suggested rotation for less than 1 month, 61% suggested rotation for 1 month and 7% for 2 months. During that period, residents are trained through video presentations, simulators, cadaver workshops, reading lists and practices on patients. Fiberoptic bronchoscope and supraglottic airway devices are frequently used in those trainings.

Wheeler et al. (39) compared the fiberoptic training managed with unaided eye with the video system assisted training and indicated the success rate to be higher in the latter. Publication of those results deeply influenced the anesthesiology societies and led to initiation of new courses. For instance, the Australian and New Zealand Societies of Anesthetists hold training courses for crisis management and create checklists. The results of selected studies are summarized in Table 1.

The method followed in non-technical skill training is to develop decision-making skills of the residents depending on algorithms in critical case scenarios through “what if” discussions. In this design, adaption of difficult airway management for daily elective cases may promote teaching. What if technique uses structured brain storming in small groups and develops alternative perspective for decision making.

In documentation of the training, the airway training certificate facilitates monitoring of repeated practices. Forming an airway training certificate for residents allows tracing the received trainings and performed practices by the resident until that period. This application may be executed using either simulators and mannequins or in the operating room in a way to cover the whole anesthesia process in order to identify weaknesses of the residents. There are studies reporting that repeating each technique for 10-20 times pave the way for the resident to become acquainted with the relevant technique and make inferences on her/his own (40).

Kirkpatrick model is another method suggested for

evaluation of training (41). This method secures objective assessment of the effectiveness of the training as well as measurement of teaching skills of the trainer. The Kirkpatrick model consists of 4 levels: The 1<sup>st</sup> level evaluates to which degree participants react favorably to the training. The 2<sup>nd</sup> level assesses to which degree participants acquire the intended knowledge, skills etc. while measuring the increase in the knowledge level as a result of training. On the other side, the 3<sup>rd</sup> level investigates to which degree participants apply what they have learned during training in real life. Ultimately, the 4<sup>th</sup> level enquires whether targeted outcomes are achieved as a result of their training or not. Specific questionnaire forms are used to evaluate each level. Hands-on practices allow residents to discuss the mistakes related to closed-loop fiber optic systems and video-laryngoscope manipulations and to bring forward suggestions so as to eliminate the identified mistakes. The memorability of the knowledge and skills acquired through hand-on practices may be enhanced in the event that the residents can give feedback on their own performances (42). Memorability of recently acquired knowledge and skills is important as it has been identified that 18% of residents need assistance during direct laryngoscopy even after 80 intubation cases. Hands-on practices may have a role in increasing patient safety.

The simple Bench model, simple mannequin models, cadavers, experimental models, the Virtual Reality Airway Simulators (VRSs) and the High-Fidelity Full-Scale Simulators are commonly used for teaching non-clinical techniques (43). These methods can never substitute the hands-on practices, but may yield successful results when combined with them.

The simple Bench models have been suggested to be effective in airway training, especially when it comes to bronchoscopy and cricothyroidotomy (44). It has been argued that residents, in this way, can gain manual skills on airway devices earlier in residency. More complicated skills may be developed through a training that starts with practices on human anatomy models and subsequently combines them with computer. Computer-combined models have features, such as voice feedback and mobility. The ‘click’ sound for dental pressure and pain feedback features of these mannequins are practical for training. VRSs are employed particularly for bronchoscopy training, and they can imitate coughing and bleeding in case of tissue damage (45). In Ireland, anesthesiology residents must participate in simulation-based courses at least for two times

Study	Design of Study	Results	Subjects	Notes
Kovasc et al. (55) <i>Ann Emerg Med</i> , 2000	Prospective randomized controlled study, n = 84.	Independent practice combined with periodic feedback was effective in maintaining performance scores in an advanced airway management simulation.	Medical students with no prior airway management experience	Simulation based study.
Donoghue et al. (57) <i>Ped Emerg Care</i> , 2013	Prospective observational cross-sectional study, n = 73.	Pediatric tracheal intubation technique can be improved by videography and videolaryngoscopy.	Physicians in pediatrics, neonatology, emergency medicine, pediatric critical care and emergency medicine	Simulation based study using video reviews of videolaryngoscopy.
Sudikoff SN et al. (67) <i>Ped Emerg Care</i> 2009	Prospective randomized crossover study, n = 16 Group 1: Simulation enhanced session on airway management Group 2: No education.	High fidelity medical simulation can be used to assess skills in management of acute pediatric airway.	Postgraduate year 2 pediatric residents	Two different computer-driven scenarios were placed and asked to manage the cases in terms of tracheal intubation, preoxygenation, cricoid pressure, RSI and teamwork.
Sullivan ME et al. (59) <i>Am J Surg</i> 2007	Prospective randomized study, n = 20, CTA Group and Control Group.	The CTA group achieved better technical competence at 1 month (CTA: 43.5 3.7, control 35.2 3.9, P .001) and at 6 months (CTA: 39.4 4.2, control: 31.8 5.8, P .004).	Postgraduate 2, 3, and 4 general surgery residents	Experts were videotaped and each resident went through a "think-out-loud protocol assessment".
Latif R et al. (13) <i>J Clin Anesth</i> , 2010	Prospective pre- and post-educational study.	Improved identification of neck anatomy, surgical landmarks, and patient positioning (pre, 2.60 ± 1.56; post, 5.64 ± 1.22; mean ± SD); use of cricothyrotomy kit (pre, 1.72 ± 1.22; post, 5.52 ± 1.26).	16 anesthesiology residents, one certified registered nurse-anesthetist (CRNA), and 8 medical students.	Pre and post tests were performed for the comfort levels of 25 subjects .
Nilsson PM et al. (68) <i>Eur J Anaesthesiol</i> , 2015	Prospective randomized controlled study, n = 23 Part task vs whole task training on virtual reality simulators.	No significant difference in final performance scores of 2 groups. Segmentation of the procedure during training is not necessary.	Anaesthesia residents in their first year of training	Accu-Touch Flexible Bronchoscopy simulator was used for training
Takayesu JK et al. (69) <i>Intern Emerg Med</i> , 2016	Pilot study, n = 23 Cadaver-based training Vs simulation training for cricothyrotomy and tube thoracostomy	The average fidelity of the cadaver vs simulation training was 79.9 ± 7.0 vs 34.7 ± 13.4 for cricothyrotomy (p < 0.0001) and 86 ± 8.6 vs. 38.4 ± 19.3 for tubethoracostomy (p < 0.0001). No significant difference for improvement in comfort levels performing procedures.	Senior EM residents PGY3 and 4	Participants were surveyed on the relative fidelity of the training using a 100 point VAS
Alam F et al. (66) <i>Adv Health Sci Educ Theory Pract</i> , 2016	Randomized, controlled, repeated measures design, n = 63, Control group, mental practice only group, Modeling only group and combined group.	In Combination Group, synergistic effects were achieved on knowledge retention, however less clear advantages in its application through clinical skills.	Medical students from years 1 to 4	
Andreatta PB et al. (70) <i>Adv Neonatal Care</i> , 2015	Comprehensive task analyses, n = 141, simulator vs live animals.	No significant differences among the cognitive, performance, and self-efficacy outcomes between models. Simulator trained subjects had significantly higher performance scores after 18 weeks (P = 0.01) and 52 weeks (P = 0.001) and cognitive scores after 52 weeks (P = 0.001). Retention of performance abilities was greater for subjects trained using the simulator.	Emergency medical services personnel, students, residents, nurses, and faculty.	Simulation provides greater opportunity for repeated practice.

Mohd Saiboon I et al. (31) <i>Med Teach</i> , 2014	Single-blinded randomized control trial, n = 45, self-instruction video vs traditional versus traditional face-to-face teaching.	No significant difference in the level of confidence and the mean OSCE-scores for both groups for basic airway management.	First year medical students	Aside from basic airway management, cervical collar application, manual cardiac defibrillation and emergency extremity splinting skills were evaluated.
Kory PD et al. (71) <i>Chest</i> , 2007	Prospective, controlled trial, n = 62, scenario-based training with a computerized patient simulator vs traditional training.	Notable differences were found in the ability to attach a bag-valve mask (BVM) to high-flow oxygen (ST group, 69%; TT group, 17%; $p < 0.001$ ), correct insertion of oral airway (ST group, 88%; TT group, 20%; $p < 0.001$ ), and achieving an effective BVM seal (ST group, 97%; TT group, 20%; $p < 0.001$ ).	Post graduate year 1 and 3 internal medicine residents	
Baker PA et al. (72) <i>Br J Anaesth</i> , 2016	Validation and reliability study, n = 28 novice vs experienced users.	ORSIM simulator is an assessment tool to measure procedural skill with a flexible bronchoscope.	Novice, trainee, and expert subjects performed seven simulations generating 196 videos for analysis.	The transfer of skills was not evaluated for patients with difficult airway in the clinical environment.
Sz cs Z et al. (73) <i>Br J Anaesth</i> , 2016	Observational cluster sampling, controlled simulation study, n = 20, cadavers vs manikins or facemask ventilation and tracheal intubation.	The success rate at first attempt at facemask ventilation was 74% on cadavers and 41% on manikins ( $P < 0.0001$ ) The incidence of Cormack-Lehane grade 3 was 17.5% in cadavers significantly higher than in manikins ( $P = 0.007$ ).	Experienced anaesthetists	Cadavers 'pre-served according Thiel's embalming method' were used.
Wise EM et al. (74) <i>Anaesth Intensive Care</i> , 2015	Prospective cadaver based comparison study n = 29	Fellows' mean direct laryngoscopy skills significantly increased after the teaching session, to a level comparable to the instructors' scores	Trainees including critical care medicine fellows and novices	POGO scores were evaluated.
Ambardekar AP et al. (26) <i>Paediatr Anaesth</i> , 2016	A simulation-based boot camp for novice pediatric anesthesiology fellows. Skills stations, team-based in situ simulations, and group discussions of complex cases were designed.	The difficult airway station and simulated scenarios improved knowledge, self-confidence, technical skill, and clinical performance.	Pediatric anesthesiology fellows	Real perioperative suite, actual operating rooms and post-anesthesia care unit were used.

Table 1  
Selected clinical reports for the airway management education.

during residency and the cost of these courses are met by the Royal College of Anesthetists of Ireland. Major advantages of simulation based training are listed in Table 2. Another important issue is grouping the trainees according to their knowledge level prior to training. The success rate may show increase in smaller groups in parallel to the training (46). As mentioned by Kristensen et al. (47) in their last editorial published in *British Journal of Anaesthesia*, the purpose of the training should correspond to the fidelity of the simulator.

The non-technical skills are as important as the technical skills and can be taught using high-fidelity simulation. Low fidelity simulators, on the other hand, are suitable for teaching the technical skills. Decision making ability, situational awareness, susceptibility to teamwork and communication are the key elements of non-technical skills, and lack of these skills prevents anesthesiologist from reaching satisfying outcomes. The key point for technical skills is to identify the frequently used or potentially life-saving maneuvers and focus on



Table 2  
Advantages of simulation based training.

<input type="checkbox"/>	Enabling the practice of rare but lifesaving airway interventions without compromising on patient safety (36).
<input type="checkbox"/>	Enhancing airway practitioner's confidence, knowledge, performance, experience and communication with both patients and patient relatives (3).
<input type="checkbox"/>	Promoting teamwork and skill training (6).
<input type="checkbox"/>	Increasing specific motor skills such as dexterity, motor control and efficiency while leading episodic memory which appears relevant for understanding learning (9).

them in trainings (48). On the other side, training programs should also take the developing medical technology into consideration (49).

#### WHAT SHOULD BE THE CONTENT OF AIRWAY TRAINING, AND HOW CAN IT BE STANDARDIZED?

The European Union of Medical Specialists should principally determine the criteria for trainers, and the trainings should process step-by-step. First of all, the trainers should be well trained so as to ensure the standards of the training to come up a certain level. In this regard, Train the Airway Trainers (TAT) courses are given actively within the European Airway Management Society (EAMS) and the course participants are oriented to organize their own workshops. The participants that successfully complete all phases become entitled to receive the Airway Teacher Diploma. It is out of doubt that assignment of well-trained trainers is of primary necessity.

Trainers should acquaint themselves with the mental model as it formulates the training by summarizing the situation and setting a roadmap (50). Mental models are necessary for completion of the psychomotor and cognitive procedures. They are quite useful especially when the team should be organized within a limited time. A mental model is mental presentation of a condition, which may potentially occur in real life. The aim of the mental models is to ensure the participants to acquire forecasting ability, formulate a plan and strategy and put those plans and strategies into practice in case of emergencies. This approach, which is based on algorithms, has been proved to be advantageous in teaching critical skills.

Ericson suggests a creative teaching method called deliberate practice (51). This approach revealed the superiority of the training that includes implementation of planned practical exercises in the way that a coach does for the athletes as teamwork. In this context, experience-based training is superior to the traditional mastery learning.

Lana and Salvodelli searched for an answer to the question "What should be the minimum gain of

training?" in their review that has been published recently (4). Researches concerning the content to be included in the basic and advanced airway training are going on (52). Anesthesiologists should have the basic airway skills –major part of the life-long airway training- before they get in the on-call state for their Institutions.

First of all, patient safety should be ensured. Subsequently, the triangle of airway, quality improvement and patient safety should be created. Residents should receive primary training and basic skills during residency. Advanced airway training should be initiated with algorithms as early as possible in residency. Combined techniques should be practiced. Residents should allocate time to training and be aware that this is a medico-legal responsibility. They should be also taught when and how long the techniques should be applied. Training should dwell upon non-technical skills. A core faculty should be formed to determine residents' individual competency for airway management as well as their theoretical and practical weaknesses.

Above all, trainers should be aware of their own responsibilities. The responsibility of airway teachers begins where the patient safety begins too. Improvement of training through participation into clinical practice is one of the cornerstones of the mechanisms enhancing patient safety.

The summary of standard airway training methods include the followings:

1. *Simulation*: The Royal College of Anesthetists now applies simulation-based training to other areas besides airway training. Also, simulation has become a part of the examination for the Primary Fellowship of the Royal College of Anesthetists (53).

There is another study, which employed videolaryngoscopy for neonatal tracheal intubation training (54). While the success rate was 66% (69/104) when the instructor viewed the videolaryngoscope screen, it decreased 41% (42/102) when the screen was covered ( $P < 0.001$ ). Regardless of whether cadaver simulator, simulation mannequin or an animal model is used, participating



in a training course does not necessarily guarantee furtherance of learning and performance. If there is a certification program at the end of which participants' eligibility to be certified, participant's performance is assessed with a more realistic approach (47).

2. *Feedback*: Trainees should be given periodic feedback, which aims to motivate trainees by underlying their learning on potentially lifesaving techniques. Feedback also boosts performance when combined with practical training (55).

3. *Airway response team*: An airway response team consisting of experienced airway instructors should be created in a hospital setting for airway management training. This method, which permits residents to participate in airway rotation and have extensive knowledge of both normal and difficult airways, has been conventionally used in the USA for years. Airway rotation should be considered as an essential sub-category of cardiovascular anesthesia or obstetric anesthesia and of ICU rotation, and thus, be included in the training program. In a study, an education program designed and carried out by the airway response team at the hospital yielded vitally significant outcomes, such as: Increased success of tracheal intubation, decreased use of neuromuscular blockers without sedation, and reduced incidence of cricotirotomy (56).

4. *Videolaryngoscopy*: As indicated in various studies, instructions through the reviews of video data that were obtained during the videolaryngoscopy practices as a part of simulation-based training promoted the success of pediatric tracheal intubation (57). Practice on an Airtraq device was stated to be beneficial for learning advanced airway management (58).

5. *Cognitive task analysis*: In this procedure, an airway expert makes critical decisions and identifies essential moments. Cognitive task analysis is used to deconstruct the automated skills of experts. The analysis provides a detailed description of the task so that the steps are more easily understood by the resident and provides information on the specific cognitive decisions that are made throughout the procedure, while accelerating the learning curve of complex cognitive technical skills (59).

6. *Video data records*: Creating video data records is another method used for bettering tracheal intubation. A study based on recording videos of real patient resuscitation in a trauma center and identifying mistakes in tracheal intubation by reviewing video records of the procedure showed that it was possible to detect the failures to use diagnostic equipment, fixation errors, and team and communication errors

through reviewing video data (60). Similarly, it was reported to be very effective to use videos/ images obtained with videolaryngoscopes during intubation of pediatric patients for educational purposes.

7. *Assessment*: Both tutor assessment and self-assessment are employed in airway management training (61). In this way, trainees can uncover their weaknesses and have opportunity to improve the weaknesses through assessments and suggestions of trainers. Additionally, participants can be sufficiently informed of the standards of the procedures as well as necessary lifesaving interventions to be applied in the case of life-threatening situations.

8. *Airway rotation*: Airway rotation has been an integral part of residency programs in the USA. This program includes completing readings list composed of books and articles on advanced airway management, learning how to use airway equipment and practicing airway management at the clinic setting which has yielded very successful results (62). A survey comparing airway instructions provided as a part of anesthesiology residency programs in Canada and the USA indicated that 49% of the respondents had formal rotations in advanced airway management (63), and two thirds of respondents had didactic lectures and practiced on mannequins.

9. *Multimodal approach*: Multimodal approach is based on the principle of the provision of airway training by a faculty composing of airway experts from different backgrounds. In a group, where pulmonologists, anesthesiologists, otolaryngologists, emergency physicians, anesthesia technicians, medical simulation experts and human factor specialists take part together, it is possible to institutionalize the provision of airway training by international instructors (64). One of the major trends used for teaching new skills and enabling rapid spread in this approach is multimedia and social media assisted instruction. When collaborative intervention is implemented through a learning network, meetings can be organized for allowing anesthesiologists to exchange knowledge and experiences. In this way, interactive sessions can be held to assess and advance airway management (65). However, it has not been possible to change difficult airway management practices through this method.

10. *Stepwise approach*: In this approach, trainees are given instructions related to normal airway and become knowledgeable with airway anatomy and respiratory physiology as the first step of airway management training. Subsequently, difficult airway management techniques are

explained (65). Theoretical lectures are followed by practice. Stepwise approach has been successfully implemented as a part of education programs for nurses and otolaryngology residents.

11. *E-learning*: Enhanced podcast increase learning of airway skills. Narration with video demonstration of skills or guided mental practice can be used (66).

### Conclusion:

In conclusion, The standard training methods employed within the scope of airway training can be listed as simulation, feedback, airway response team, videolaryngoscopy, cognitive task analysis, video data records, assessment, airway rotation, multimedia approach, stepwise approach and e-learning. The main limitations include the effective use of fresh frozen cadavers, ethical considerations in animal studies and the challenge of moving simulation based knowledge into clinical practice.

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