

ORIGINAL RESEARCH

Airway management education in medical students: a cross-sectional study of knowledge and practical experience

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ABSTRACT

INTRODUCTION:

Airway management is a fundamental clinical skill, and failure to secure the airway remains a major cause of morbidity and mortality.

OBJECTIVE:

To assess medical students' knowledge and practical competence in airway management.

METHODS:

A cross-sectional study was conducted among 79 medical students using a structured, anonymous questionnaire administered to 5th- and 6th-year students at the School of Medicine, University of Zagreb.

RESULTS:

Most students (94.9%) reported that endotracheal intubation should be included in undergraduate training. Basic airway maneuvers were well recognized, while advanced techniques such as laryngoscopy were identified by over 90% of participants. Fewer students (75.9%) recognized supraglottic airway devices. Practical experience was limited: 65.8% had placed a supraglottic airway device on a mannequin, but only 15.2% on a patient. Similarly, 59.5% had performed intubation on a mannequin compared with 19.0% on patients.

CONCLUSION:

While theoretical knowledge is strong, practical experience—particularly with advanced airway techniques—is limited. Enhanced structured and simulation-based training is needed to improve competence and patient safety.

Keywords: Airway Management; Students, Medical; Education, Medical, Undergraduate; Clinical Competence; Simulation Training

Introduction

Airway management is a key skill acquired during medical education and is widely used in various specializations, most notably in anesthesiology and emergency medicine (1). Failure to secure the airway remains a leading cause of patient morbidity and mortality. According to the Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society, the main reasons for that are poor judgement, inadequate skill, and unproductive behaviour (2). Good education is key to resolving this problem. It should start at the beginning of a medical career and be revisited throughout, to maintain and learn new upcoming skills (3). The main barriers to effective airway management training in undergraduate medical curricula for medical students include the lack of formal, structured curricula, insufficient hands-on exposure, limited access to

simulation resources, variability in training content and frequency, and inadequate assessment and feedback mechanisms. Most medical students report inadequate exposure to airway emergencies and altered airway anatomy, such as tracheostomy and laryngectomy care, which leads to low confidence and proficiency in managing these scenarios (4,5). Training is often opportunistic and relies on clinical rotations, resulting in inconsistent skill acquisition and retention (3,6). Simulation-based training, while effective, is not universally available or standardized, and many programs lack regular, competency-based assessment (7–9). Over the years, teaching strategies have changed, as well as student generations. It is shown that simulation is an effective way for the development of psychomotor skills and clinical judgment, allowing students to practice in a controlled environment without risking the patient harm (10,11). The traditional method of airway management education uses experiential learning during patient care in the operating room (3). Endotracheal intubation using a video laryngoscope may be appropriate in this context because it allows instructors to directly observe students' intubation attempts via the device's video screen (12). Another possibility, if acceptable for surgery, is the placement of a laryngeal mask airway, which is easier and faster. Despite its limitations, it is believed that simulator training before going to the operating room has a positive impact on students' acquisition of procedural and patient safety skills, although it has not yet been confirmed in published studies (13). It is said that the best learning is from mistakes; however, mistakes in the operating room are unacceptable. On the other hand, supervised mistakes in simulation labs are recommended. Effective training requires experienced instructors, high-fidelity simulators, and well-designed curricula (14). The problem is that high-fidelity simulators are expensive and not widely available. This creates an opportunity for implementing Artificial Intelligence (AI) in education, as it allows affordable virtual reality solutions. In a randomized controlled trial involving practicing on low-fidelity mannequins simulating difficult airway scenarios, students using the Vortex Approach demonstrated improved decision-making and reduced anxiety during airway management tasks (15). A systematic review and meta-analysis of advanced airway management training also found that stimulation techniques were associated with higher learner satisfaction and highlighted that curricula including course repetition, ongoing practice with or without evaluation and feedback, and use of self-regulated learning appear effective in airway management skill retention and should be incorporated for those requiring skills maintenance (7). In today's era of smartphones, anesthesiology learning applications have been developed. Some of them include Anesthesiologist (16), The Difficult Airway App (17), and NYSORA Anesthesia Assistant, which is powered by AI (18). Using these applications, students can better prepare for airway management training. Northwestern University has developed a virtual reality software application called iLarynx, which uses the accelerometer properties of the iPhone® or iPad® (Apple Inc., Cupertino, CA, USA) to mimic hand movements for performing fiberoptic skills (19). Their analysis showed a significant improvement in upper airway endoscopy skills among medical students.

At the University of Zagreb School of Medicine, these skills are part of the curriculum in several courses: First Aid in the 1st year, Anesthesiology and Reanimatology in the 5th year, and Fundamentals of Medical Skills throughout all six years of study (20). The lockdown during the COVID-19 pandemic taught us that high-tech learning has its advantages, but during other types of disasters, when infrastructure is disrupted, electricity is out, high-tech devices are not working or are unavailable, and patients are emerging, back-to-basic and old-school techniques are the only options available if we know how to use them. Having this in mind, during courses that teach airway management, we teach our students all available techniques, but most importantly, basic ones that can be used everywhere if you are confident in your skills. To find out the situation on the ground and potential gaps between curricula and real-life practice at the School of Medicine, University of Zagreb, the following study was performed.

Methods

Study design and setting:

This cross-sectional study was conducted during the 2024/2025 academic year at the University of Zagreb School of Medicine.

Participants:

Eligible participants were 5th- and 6th-year medical students. Participation was voluntary and anonymous. No exclusion criteria were applied.

Data collection and variables:

Data were collected using a structured, anonymous online questionnaire (Google Forms), distributed twice via the institutional learning management system and student WhatsApp groups, with approval from the Department of Anesthesiology, Reanimatology and Intensive Care Medicine of Surgical Specialties.

The questionnaire comprised seven items assessing: (1) year of study and attendance in the Anesthesiology and Reanimatology course; (2) attitudes toward inclusion of endotracheal intubation in undergraduate teaching; (3) knowledge of basic and advanced airway management techniques; and (4) perceived importance, acquisition, and setting of airway management skills.

Bias:

To reduce non-response bias, the survey was distributed twice through multiple communication channels.

Study size:

All eligible students were invited to participate; no formal sample size calculation was performed.

Statistical methods:

Data were analyzed descriptively and presented as frequencies and percentages in tables and figures.

Results

A total of 79 medical students participated in the survey out of 528 students enrolled in the 5th- and 6th-year. Table 1 shows participants' years of study and their attendance in the Anesthesiology and Reanimatology course. More than half of the participants were 5th-year medical students (N=43; 54.4%), and most participants completed the course at the School of Medicine (N=56; 70.9%).

Almost all participants thought that endotracheal intubation should be taught during medical school (N=75; 94.9%), while only 2.5% (N=2) disagreed. Solely 1.3% (N=1) thought that professors should only demonstrate the procedure without need for them to have any hands-on experience, and 1.3% (N=1) were unsure.

Results about basic airway management methods or maneuvers are shown in Figure 1. Regarding this question, all participants (N=79; 100.0%) identified head tilt, 94.9% (N=75) chin lift, and 93.7% (N=74) jaw thrust. Placement of an oropharyngeal and nasopharyngeal tube was identified by 49.4% (N=39), and bag-valve-mask ventilation by 35.4% (N=28).

Figure 2 shows the results regarding which of the following are advanced airway management methods. Most participants recognized that endotracheal intubation using direct laryngoscopy (N=72; 91.1%) and indirect laryngoscopy (N=73; 92.4%) were advanced methods. Placement of a supraglottic device was selected by 75.9% (N=60), fiberoptic intubation by 74.7% (N=59), retrograde intubation by 50.6% (N=40), and cricothyroidotomy by 2.5% (N=2) of participants.

Table 2 shows what medical students think they should learn during their studies. Bag-valve-mask ventilation and endotracheal intubation using direct laryngoscopy were selected by 74 (93.7%) participants, while oropharyngeal tube placement by 77 (97.5%). Placement of a nasopharyngeal tube was chosen by 66 (83.5%) and a supraglottic device by 59 (74.7%). Almost half (N=38; 48.1%) would like to learn how to perform cricothyroidotomy. Interestingly, only 35.4% (N=28) wanted to learn endotracheal intubation using video laryngoscopy and only 15.2% (N=12) thought fiberoptic intubation should be taught.

The level of students' experience in airway management varied, as shown in Table 3. More than half of them (N=52; 65.8%) had placed a laryngeal mask airway device on a mannequin, mostly during the Fundamentals of Medical Skills course and the Anesthesiology and Reanimatology course. On the other hand, only 12 (15.2%) students had placed a laryngeal mask airway device on a patient under supervision. Endotracheal intubation using direct laryngoscopy on a mannequin was attempted by 47 (59.5%) students, while merely 15 (19.0%) attempted it on a patient under supervision. Endotracheal intubation using video laryngoscopy was endeavored by 8 (10.1%) students on a mannequin and by 9 (11.4%) on a patient under supervision. Both were performed during the Anesthesiology and Reanimatology course.

Table 1. Participant's year of study and attendance in the Anesthesiology and Reanimatology course

Question	Answer	Number (%)
Year of study	5th-year	43 (54.4)
	6th-year	36 (45.6)
Attendance in the Anesthesiology and Reanimatology course	Yes	56 (70.9)
	No	23 (29.1)

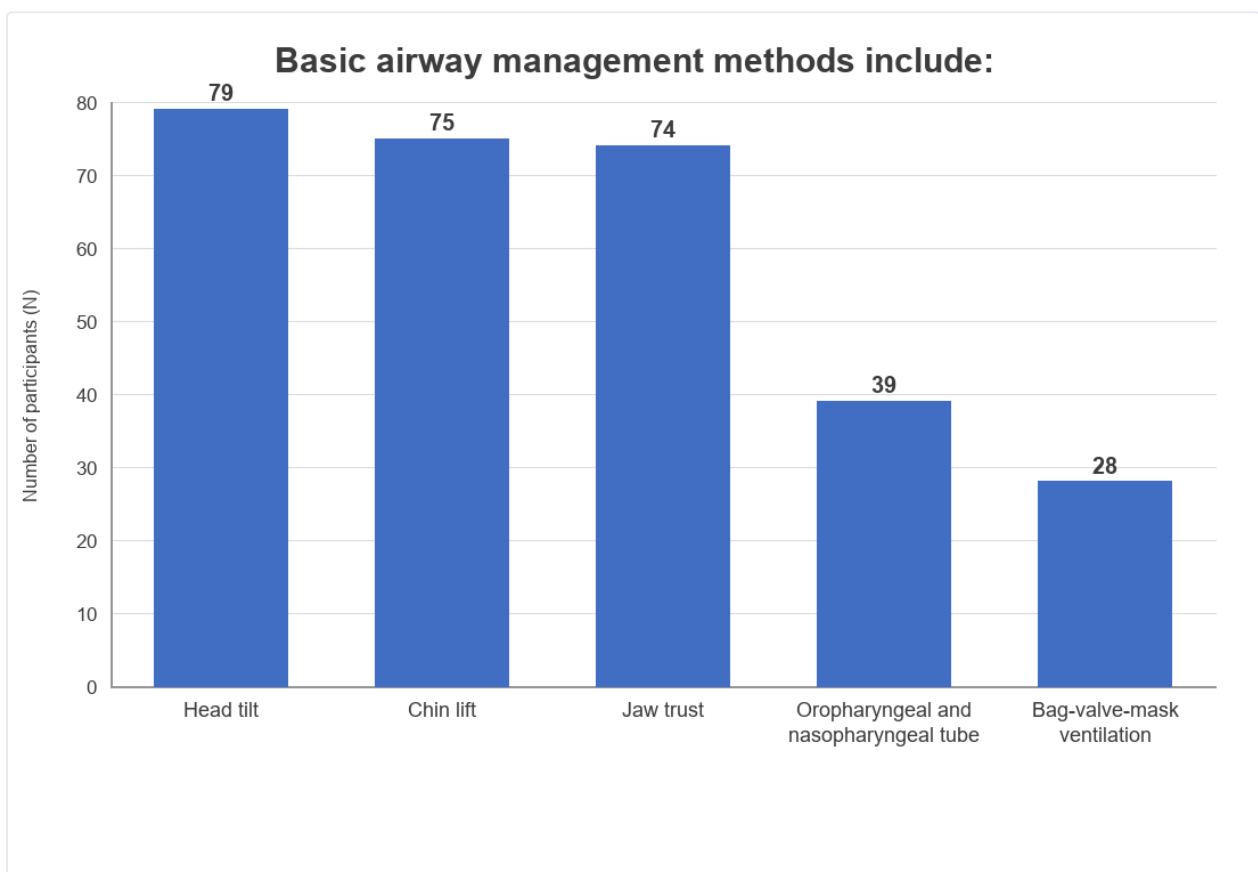


Figure 1. Participant's knowledge about basic airway management methods

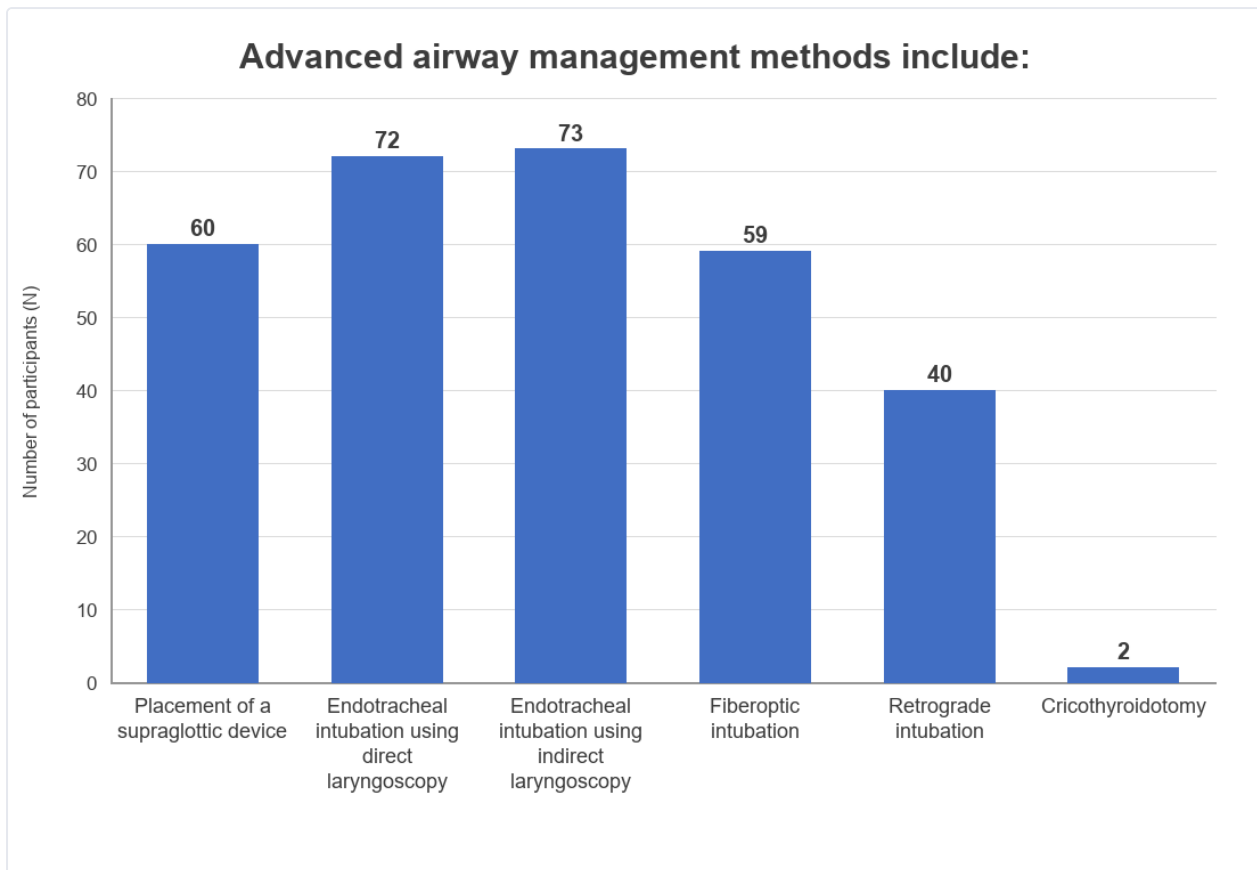


Figure 2. Participant's knowledge about advanced airway management methods

Table 2. Participants' opinion on what they should learn during medical school

I should learn in medical school:	Number (%)
Bag-valve-mask ventilation	74 (93.7)
Placement of a supraglottic device	59 (74.7)
Endotracheal intubation using direct laryngoscopy	74 (93.7)
Endotracheal intubation using indirect laryngoscopy	28 (35.4)
Cricothyroidotomy	38 (48.1)
Placement of an oropharyngeal tube	77 (97.5)
Placement of a nasopharyngeal tube	66 (83.5)
Fiberoptic intubation	12 (15.2)

Table 3. Participant's level of experience in airway management (LMA – laryngeal mask airway; DL – direct laryngoscopy; VL – video laryngoscopy)

	Yes	No	Yes, but unsuccessfully	Fundamentals of Medical Skills	First Aid	Anesthesiology and Reanimatology	Other
LMA on a mannequin	52 (65.8)	8 (10.1)	2 (2.5)	30 (40.0)	5 (6.3)	33 (41.8)	4 (5.1)
LMA on a patient under supervision	12 (15.2)	61 (77.2)	1 (1.3)	3 (3.8)	1 (1.3)	7 (8.9)	5 (6.3)
Endotracheal intubation using DL on a mannequin	47 (59.5)	10 (12.7)	3 (3.8)	34 (43.0)	1 (1.3)	31 (39.2)	6 (7.6)
Endotracheal intubation using DL on a patient under supervision	15 (19.0)	54 (68.4)	5 (6.3)	1 (1.3)	0	8 (10.1)	7 (8.9)
Endotracheal intubation using VL on a mannequin	8 (10.1)	66 (83.5)	0	0	0	3 (3.8)	7 (8.9)
Endotracheal intubation using VL on a patient under supervision	9 (11.4)	68 (86.1)	0	0	0	2 (2.5)	3 (3.8)

Discussion

This study demonstrates that medical students at the University of Zagreb School of Medicine possess strong theoretical knowledge of airway management. Most participants had attended the Anesthesiology and Reanimatology course and correctly identified both basic and advanced airway management techniques at the time of questionnaire distribution. In particular, nearly all respondents agreed that endotracheal intubation should be included in undergraduate training, reflecting awareness of its central role in airway management in both anesthesiology and emergency medicine.

Basic airway maneuvers, including head tilt, chin lift, and jaw thrust, were widely recognized, likely reflecting their early introduction during first aid training and reinforcement throughout the curriculum, consistent with previous studies (3,21,22). In contrast, fewer students identified certain techniques such as bag-valve-mask ventilation and supraglottic airway devices, suggesting variability in exposure and retention of these skills. Similarly, although most participants recognized endotracheal intubation, fewer were familiar with less commonly performed advanced techniques such as fiberoptic or retrograde intubation (23,24), which are typically not emphasized in undergraduate training.

Despite strong theoretical knowledge, practical experience was limited. While many students reported experience with airway techniques on mannequins primarily during structured courses (25) fewer than one in five had performed procedures such as laryngeal mask airway placement or endotracheal intubation on patients under supervision (26). This gap may reflect limited clinical exposure, time constraints during rotations, and restricted access to operating room training opportunities.

Students identified key airway management skills that should be included in undergraduate education, particularly basic airway techniques, supraglottic device placement, and direct laryngoscopy. These findings support the need for structured, competency-based training. Simulation-based education plays a crucial role in addressing limited clinical exposure, enabling repeated practice in a safe environment; however, it does not fully replace supervised clinical experience. It enables contact with decision-making under stress, complication management, and non-technical skills such as teamwork and situation-awareness, while having an expert supervision to step-in during difficult airway situations.

Overall, the findings highlight a gap between theoretical knowledge and practical competence. Addressing this gap through enhanced, structured, and simulation-based training combined with increased opportunities for supervised clinical practice may improve skill acquisition, confidence, and ultimately patient safety. To achieve this, Department could propose structured training pathways, minimum procedural requirements, or integration of longitudinal airway training across different years of study. Another solution is to implement objective assessment methods like objective structured clinical examination (OSCE) or simulation scoring on mannequins at the end of the Anesthesiology and Reanimatology course (27).

This study provides a focused evaluation of both knowledge and practical exposure to airway management among senior medical students within a defined curriculum. It captures perspectives from students at a critical stage of training, integrating both cognitive and experiential aspects of learning. The use of a structured questionnaire enabled consistent data collection across participants, offering insight into current educational outcomes and areas for improvement.

Limitations:

The findings should be interpreted in light of the relatively low response rate (79/528), which may introduce non-response bias and limit generalizability. The survey was distributed twice via the institutional learning management system and WhatsApp groups; however, participation remained limited. Additionally, the data is self-reported, and participants might underestimate or overestimate their competence.

Conclusion

Medical students demonstrate strong theoretical knowledge of airway management, including advanced techniques; however, practical experience—particularly with procedures such as endotracheal intubation—remains limited. These findings highlight a gap between knowledge and clinical performance. Expanding structured, supervised, and simulation-based training within undergraduate curricula is essential to improve competence, confidence, and patient safety.

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Cite as: Plaftak T, Curić Radivojević R, Jurakić K, Bandić Pavlović D, Tonković D. Airway management education in medical students: a cross-sectional study of knowledge and practical experience. *CJAIM* 2026;2(1):6–13.

