Evaluation of advanced airway management in absolutely inexperienced hands: a randomized manikin trial

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Aims **Endotracheal intubation (ETI) and basic ventilation techniques (i.e. mouth-to-mouth/nose, bag-valve-mask ventilation) require skills and training. As an alternative, supraglottic airway devices (SAD) are efficient and technically easy to insert. We therefore evaluated the time to ventilation, success rate, and skill retention for various airway management approaches by medical laypersons using a manikin model.**

Methods **Fifty medical laypersons with no previous experience whatsoever in airway management or resuscitation were enrolled. All participants received a 1-h-long theoretical lecture and a practical demonstration of mouth-to-mouth ventilation, ETI, and six SAD. Afterwards, the laypersons performed mouth-to-mouth ventilation and used each of the seven airway-management systems on an advanced patient simulator (SimMan) in a random sequence. All participants were re-evaluated 3 months later without any further practical or theoretical demonstration.**

Results **The success rates for ETI were 74% during the first evaluation and 64% during the second, whereas the success rate for all six SAD was 100% during all application attempts. The success rate for mouth-to-mouth ventilation was 86% initially and 84% 3 months later. The time to adequate mouth-to-mouth ventilation was 15±13 s initially and 16±7 s subsequently. ETI required 53±21 s during the initial evaluation and 44±16 s 3 months later.**

Conclusion **A variety of SAD all proved to reliably secure airways quickly, even in the hands of complete novices. The SAD were much more effective than ETI, which often failed, and were even superior to mouth-to-mouth ventilation. SAD may thus be an appropriate first-line approach to field ventilation.** ***European Journal of Emergency Medicine*** **20:310–314 © 2013 Wolters Kluwer Health | Lippincott Williams & Wilkins.**

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Introduction

The importance and necessity of airway management during cardiopulmonary resuscitation (CPR) remains controversial [1]. Currently, a nationwide campaign in the UK proposes chest compressions only during CPR. However, current guidelines for CPR include three essential cornerstones: securing the airway and ventilation, chest compressions, and electrical defibrillation if indicated [2–4].

The fastest and easiest way to perform artificial ventilation is mouth-to-mouth or mouth-to-nose; in contrast, effective bag-valve-mask ventilation requires considerable skills [5]. Laypersons often refrain from basic forms of ventilation because of exposure to vomitus and blood or because of fear of failure. Common 'technical' problems are poor head extension and ineffective seal. These may lead to a lack of ventilation, stomach insufflation, and the consequent risk of aspiration and air leak in up to 40% of cases – even in experienced hands [6].

Endotracheal intubation is still considered the 'gold standard' for securing and maintaining a patent airway. However, successful endotracheal intubation requires a high level of expertise along with regular training and practice [7–9], and should therefore be avoided by inexperienced personnel. A further complexity is that airway skills degrade rapidly over time without regular practice [10]. Some experts thus suggest that inexperienced laypersons should completely refrain from the performance of ventilation during basic life support because of its low efficiency and even potential harm [11].

As alternatives to endotracheal intubation, supraglottic airway devices are less invasive and technically easier to insert [12]. Recent studies in various settings and with staff with various levels of expertise report that supraglottic airway devices provide better success rates, short interruption of 'hands-off time' during CPR, and an overall high safety and efficacy [12,13]. Supraglottic

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airway devices thus represent a valuable option in patients with anticipated or unanticipated difficult airways [14,15].

Whether supraglottic airway devices can be successfully used by essentially naive laypersons remains unknown. We therefore evaluated the success rates and time to ventilation with mouth-to-mouth ventilation, endotracheal intubation, and various supraglottic airway devices in a manikin model. The extent to which laypeople retain a brief airway experience over time is also unknown. We therefore re-evaluated the success rates and time to ventilation with each device 3 months after the initial test. Specifically, we tested the hypothesis that the success rates and time to ventilation are significantly better with supraglottic airway devices than with endotracheal intubation and mouth-to-mouth ventilation, and that airway skills are well maintained over time.

Materials and methods

After receiving the approval of the local Ethics Committee of the Medical University of Vienna and informed consent, 50 medical laypersons were enrolled in this study. The lay participants were Austrian medical students in the first month of education, which is equivalent to beginning college students in the USA. The data of this study were collected in October, respectively, in December 2010. None had any previous experience in airway management or resuscitation.

All participants listened to a lecture lasting for 60 min covering anatomical and physiological basics, the principles of mouth-to-mouth ventilation, and the different airway devices for securing an airway. Following the lecture, a practical demonstration of mouth-to-mouth ventilation and all different airway devices on a manikin was performed individually for each student by an experienced anesthetist. However, the students were not allowed any personal hands-on practice. Airway management with the following seven airway devices was demonstrated:

(1) Intubating laryngeal mask (Fastrach single use, LMA Company North America, San Diego, California, USA) size 4.
(2) Supreme (LMA Company North Americ) size 4.
(3) Laryngeal tube (VBM Medizintechnik GmbH, Sulz, Germany) size 4.
(4) I-Gel (Intersurgical Ltd., Wokingham, England) size 4.
(5) Combitube (Covidien, Mansfield, Massachusetts, USA) SA 37F.
(6) Easytube (Teleflex Medical, Research Triangle Park, North Carolina, USA), 41F.
(7) Laryngoscopic-guided endotracheal intubation (7.5 mm ID, Mallinckrodt, Athlone, Ireland) reinforced with a rigid bougie.

Each medical student performed airway management with all seven airway devices and mouth-to-mouth ventilation in a computer-generated randomized sequence using the randomizer software of the Institute of Statistics of the Medical University of Vienna (*https://www.muw.ac.at/randomizer/web/login.php*). Airway management was performed with an advanced patient simulator SimMan (Laerdal Medical, Stavanger, Norway), which was placed supine on the floor for all evaluations. The design of this training instrument allows the simulation of the airway in a plastic manikin and is widely recognized as an effective learning tool [16,17]. The airway of the manikin as well as the devices were wetted thoroughly with the lubricant recommended by Laerdal. Medical students were not allowed to watch each other, to avoid any observational teaching bias or learning effect. When necessary, syringes for cuff insufflations were already connected before insertion.

Three months later, all 50 medical students participated in a second evaluation. No further practical or theoretical demonstration had been provided in the meantime, and each confirmed a lack of extracurricular airway experience. Airway management was performed with mouth-to-mouth ventilation and all seven airway devices, again in a randomized sequence.

Repositioning was allowed if misplacement was identified by the medical students. Airway management attempts lasting longer than 120 s were defined as a failure and medical students were told to stop at that time.

The primary outcome was time to ventilation, beginning with picking up the airway device or the laryngoscope, and ending with the first visible ventilation of the lungs in the absence of gastric inflation. The success rate, defined by securing the airway within 120 s, was one secondary outcome. The other was the change in time to ventilation between the initial evaluation and the subsequent evaluation 3 months later.

Statistical analysis

Time to ventilation and airway placement success were analyzed using a mixed-effects model accounting for the repeated measurements in the participants and with pairwise comparisons between the airway management groups. Correction for multiple testing was performed according to Bonferroni and P values were adapted accordingly.

On the basis of the expected average variance of time to ventilation of $\sim$30% and a SD of $\pm$30%, 43 medical students were required to obtain 90% power at an α level of 0.05. We thus enrolled 50 students in the trial.

Continuous data were tested for normal distribution using the Shapiro–Wilk test. Normally distributed data were described by the mean and SD and compared using

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a paired *t*-test. Success rates were compared using χ^2-tests. We used a two-sided test with an α level of 0.05.

All analyses were carried out using the STATA software package (Stata Statistical Software: Release 11, Stata Corp LP, College Station, Texas, USA).

Results

Fifty first-year medical students (29 women and 21 men, age 21±2 years) of the Medical University of Vienna participated in our study. The results for all eight airway management methods (mouth-to-mouth, endotracheal intubation, and six supraglottic airways) were available for both evaluations.

Time to ventilation using endotracheal intubation took 53±21 s during the initial evaluation and 44±16 s during the second evaluation. Although time to ventilation decreased significantly, faster tube insertion was accompanied by a lower intubation success rate: 74% initially versus 64% 3 months later. Time to ventilation for mouth-to-mouth ventilation was about 15 s on both the first and the second evaluation, but the success rate was only about 85% on each evaluation.

During the first evaluation, the laryngeal tube (11±3 s) and the I-Gel (12±3 s) were the fastest supraglottic airway devices. The Combitube took 17±3 s and was the slowest supraglottic airway device. The times to ventilation of the other supraglottic airway devices were intermediate: Fastrach 14±4 s; Supreme 15±3 s; and EasyTube 17±3 s. During the second evaluation, airway management using I-Gel was the fastest (10±2 s), whereas EasyTube was the slowest (18±3 s). All other supraglottic airway devices were intermediate (Table 1).

All supraglottic airway devices were inserted successfully during all intubation attempts. The success rates for each supraglottic airway device were significantly greater than for endotracheal intubation and mouth-to-mouth ventilation during both the initial (Table 2) and the 3-month (Table 3) evaluations.

Table 1 Time to ventilation

	First evaluation	Second evaluation	*P* value
Endotrachial intubation	53±21	44±16	**<0.001**
Mouth-to-mouth	15±13	16±7	0.007
Combitube	17±3	17±3	0.638
EasyTube	17±3	18±3	0.155
Fastrach	14±4	14±4	0.837
Supreme	15±3	15±2	0.774
Laryngeal tube	11±3	12±3	0.353
I-Gel	12±3	10±2	**0.006**

Results expressed as means±SDs. Significance levels were corrected for multiple testing using the Bonferroni method (*P* values ≤ 0.006 are significant). Bold indicates statistical significance.

Discussion

Recent guidelines of the European Resuscitation Council suggest that airway devices should be inserted within 10 s [2]. Previous studies have reported that success rates and time to ventilation depended on individual experience and training [7–8,18]. Consequently, experienced doctors are usually able to perform endotracheal intubation within the recommended time frame, whereas less experienced medical staff often fail – and should therefore completely refrain from endotracheal intubation [2,13]. Our results are consistent with this advice: endotracheal intubation took a long time and failed in more than a quarter of all intubations, a fraction that would be completely unacceptable in real clinical situations. Prolonged and frequently unsuccessful intubation was similarly observed in our previous study of less experienced medical staff (i.e. paramedics), who also performed poorly [13].

Mouth-to-mouth ventilation also worked poorly – although mouth-to-mouth, mouth-to-pocket-mask, and bag-valve ventilation have long been recommended for out-of-hospital use by laypeople. Although perhaps surprising, our results are generally consistent with previous work. Adelborg *et al.* [19], for example, recently reported, that mouth-to-mouth ventilation was more likely to be effective than mouth-to-pocket-mask and bag-valve ventilation. Alexander *et al.* [20] showed that basically trained volunteers successfully performed bag-valve ventilation only 43% of the time. The same team reported in another study that pocket mask ventilation failed half the time [21]. These results are basically in agreement with the results of Paal *et al.* [22] who reported that pocket mask ventilation was sufficient only 32% of the time, mouth-to-mouth shield ventilation was sufficient only 19% of the time, and mouth-to-mouth fared the worst, being sufficient only 17% of the time. An additional difficulty with mouth-to-mouth and bag-valve-mask ventilation is a higher risk of aspiration than with laryngeal mask ventilation: laryngeal mask ventilation (3%), bag-valve-mask ventilation (12%), and mouth-to-mouth ventilation (25%) [23,24].

Although our inexperienced participants frequently failed to provide adequate ventilation through intubation or with mouth-to-mouth breathing, they were uniformly able to quickly insert each of the six supraglottic devices we tested. After just a single theoretical lecture and practical demonstration without hands-on training, junior medical students secured the airway in a manikin with various supraglottic airway devices in 10–17 s, which is not appreciably longer than the time recommended by the 2010 guidelines of the European Resuscitation Council [2].

Our results are consistent with previous studies of minimally experienced paramedics, nurses, and senior medical students who also achieved good success with supraglottic airways [13,20,25,26]. Wiese *et al.* [27] and Wharton *et al.* [28] also showed that I-Gel airways can be inserted in 9–18 s. Russi *et al.* [29] and Tumpach *et al.* [30]

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Table 2 Level of significance comparing time to ventilation for various airway devices the initial evaluation

	Endotracheal intubation	Mouth-to-mouth	Combitube	EasyTube	Fastrach	Supreme	Laryngeal tube
Mouth-to-Mouth	**<0.001**	–	–	–	–	–	–
Combitube	**<0.001**	0.319	–	–	–	–	–
EasyTube	**<0.001**	0.31	0.698	–	–	–	–
Fastrach	**<0.001**	0.441	**<0.001**	**<0.001**	–	–	–
Supreme	**0.001**	0.937	**0.001**	**0.002**	0.02	–	–
Laryngeal tube	**<0.001**	0.073	**<0.001**	**<0.001**	**<0.001**	**<0.001**	–
I-Gel	**<0.001**	0.073	**<0.001**	**<0.001**	0.003	**<0.001**	0.449

Significance levels were corrected for multiple testing using the Bonferroni method (P values ≤ 0.002 are significant).
Bold font indicates statistical significance.

Table 3 Level of significance comparing the different airway devices at the second evaluation

	Endotracheal intubation	Mouth-to-mouth	Combitube	EasyTube	Fastrach	Supreme	Laryngeal tube
Mouth-to-mouth	**<0.001**	–	–	–	–	–	–
Combitube	**<0.001**	0.253	–	–	–	–	–
EasyTube	**<0.001**	0.253	0.809	–	–	–	–
Fastrach	**<0.001**	0.282	**<0.001**	**<0.001**	–	–	–
Supreme	**<0.001**	0.058	**<0.001**	**<0.001**	0.066	–	–
Laryngeal tube	**<0.001**	**<0.001**	**<0.001**	**<0.001**	0.008	**<0.001**	–
I-Gel	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**0.002**

Significance levels were corrected for multiple testing using the Bonferroni method (P values ≤ 0.002 are significant).
Bold font indicates statistical significance.

reported a high success rate and comparable fast insertion times for the laryngeal tube. Kette *et al.* [31] showed in 30 cardiac arrest patients that the laryngeal tube was successful in 90%. Studies also show that the Combitube and its extension, the EasyTube, are useful airway devices, especially for less experienced staff [13,32]. Finally, our results with the Supreme airway fully support the report by Howes *et al.* [33] that the median insertion time in manikins is 15 s.

Although there were a few statistically significant differences between the initial and the subsequent airway management experiences, there was no clinically significant learning or forgetting over the 3-month test period. For example, intubation was faster at 3 months, but the success rate was lower – and intubation was not even close to being clinically acceptable in terms of speed or accuracy at either test. Our results nonetheless indicate that whatever skill was gained in a brief lecture and demonstration was well maintained over time even without reinforcement.

A limitation of our study was the use of a manikin model instead of patients. Although manikin-based airway simulators remain controversial, the Laerdal Manikin seems to be one of two manikins suitable for the use of a wide variety of supraglottic airway devices [34]. However, the use of a manikin avoided the ethical challenges of airway management in patients by completely inexperienced operators. Furthermore, the manikins we used are among the best available for airway simulations. Finally, the use of manikins allowed us to use a statistically powerful cross-over study design [16,17].

Conclusion

In summary, completely inexperienced laypeople were able to quickly establish effective ventilation with each of the supraglottic airways we tested – Combitube, EasyTube, Fastrach, Supreme, laryngeal tube, and I-Gel. Our results thus support the suggestion by Paal *et al.* [35] that bag-valve-mask ventilation will lose its prominence during basic life support in favor of supraglottic airway devices. We similarly agree with Nolan and Soar [36] that supraglottic airway devices are the logical alternative to tracheal intubation when airway management is undertaken by inexperienced or minimally skilled individuals. In contrast, neither endotracheal intubation nor even mouth-to-mouth ventilation are effective in the hands of inexperienced operators. Therefore, supraglottic airway devices seem to be a practicable alternative in inexperienced hands and could potentially serve as a useful addition to chest compression only and AED in first aid. Nevertheless, larger randomized-controlled trials on this are essential for further recommendations.

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Conflicts of interest

Michael Frass invented the Combitube and has received royalties from Covidien. The remaining authors have no conflicts of interest.

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