Simulation and education

Hands-off time during insertion of six airway devices during cardiopulmonary resuscitation: A randomised manikin trial

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A R T I C L E   I N F O

Article history:
Received 6 March 2011
Received in revised form 17 March 2011
Accepted 24 March 2011

Keywords:
Anesthesia
Paramedics
Endotracheal intubation
Supraglottic airways
Emergency airway management
CPR

A B S T R A C T

Introduction: Cardiopulmonary resuscitation (CPR) guidelines recommend limiting interruptions of chest compressions because prolonged hands-off (i.e., non-compression) time compromises tissue perfusion. 2010 European Resuscitation Council guidelines suggest that chest compressions should be paused less than 10 s during airway device insertion.

Methods: With approval of the local ethics committee of the Medical University of Vienna and written informed consent, we recruited 40 voluntary emergency medical technicians, none of whom had advanced airway management experience. After a standardised audio-visual lecture and practical demonstration, technicians performed airway management with each six airway devices (endotracheal tube, Combitube, EasyTube, laryngeal tube, Laryngeal Mask Airway, and I-Gel) during on-going chest compressions in a randomised sequence on a Resusci Anne Advanced Simulator. Data were analysed using a mixed-effects model accounting for the repeated measurements and pair-wise comparisons among the airway devices.

Results: The hands-off time associated with airway management using an endotracheal tube (including all intubation attempts) was 48 s (95% confidence interval: 43–53). The hands-off time for airway management using a laryngeal tube was 8.4 (3.4–16.4) s, Combitube 10.0 (4.9–15.1) s, EasyTube 11.4 (6.4–16.4) s, LMA 13.3 (8.2–18.3) s and for I-Gel 15.9 (10.8–20.9) s. Hands-off time was significantly longer with the conventional endotracheal tube than with any of the other airway systems. Only a third of the technicians successfully inserted an endotracheal tube whereas all of them successfully positioned each supraglottic device.

Conclusion: Supraglottic devices appear to be a reasonable emergency airway management strategy, even for inexperienced personnel.

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1. Introduction

In emergency situations, ventilation and oxygenation of patients can be life-saving.1–3 Endotracheal intubation remains the standard approach for securing and maintaining a patent airway.4,5 However, endotracheal intubation requires highly skilled and experienced personnel, along with regular training and practice.6–11 Endotracheal intubation is thus best performed by experienced personnel to reduce the risk of unrecognised esophageal intubation and catastrophic clinical consequences.4 Supraglottic airway devices are less invasive than intubation and are technically easier to insert.12 They may well speed time to adequate ventilation, especially in patients with difficult airways.13–15

Nearly continuous CPR chest compressions are required to maintain tissue perfusion. Consequently, 2010 European Resuscitation Council guidelines suggest that chest compressions should be paused only briefly for insertion of airway devices, preferably less than 10 s.4 Pauses in chest compressions, especially those associated with airway management, are considered “hands-off”
time.\textsuperscript{4,16,17} We thus used a manikin model to test the hypothesis that airway control during cardiopulmonary resuscitation is secured faster and with greater success with supraglottic airway devices than with conventional intubation.

2. Methods

With approval of the local ethical committee of the Medical University of Vienna (identifier 900/2010) and written informed consent, 40 active voluntary emergency medical technicians of the Red Cross Burgenland, Austria, were recruited in January 2011. Austrian emergency medical technician training differs from that in Germany or the United States. Basic airway management is strictly limited to bag-valve ventilation; in contrast, advanced airway management—including endotracheal intubation—requires further training. We recruited only technicians without previous formal or practical training in advanced airway management.

2.1. Protocol

All participants attended a 1-h-long standardised audio-visual lecture covering relevant aspects of anatomy, CPR, and different techniques for securing an airway. Thereafter, they attended a demonstration in which airway management was demonstrated on an advanced patient simulator Resucsi Anne Advanced Simulator (Laerdal Medical, Stavanger, Norway). Demonstrations were conducted in the context of on-going chest compressions, using the following six airway devices:

1. Laryngoscopic guided endotracheal intubation 7.5 mm ID. (Mallinckrodt, Athlone, Ireland), reinforced with a stylet;
2. Combitube SA 37 F (Covidien, Mansfield, MA, USA);
3. Easytube Ch 41 (Teleflex Medical, Research Triangle Park, NC, USA);
4. Laryngeal tube disposable size 4 (Knight-LT-D, VBM, Sulz, Germany);
5. Laryngeal mask unique – LMA size 4 (LMA Company North America, San Diego, CA, USA);

The technicians then performed standardised two- rescuer CPR according to the European Resuscitation Council guidelines including chest compressions and bag-valve ventilation (ratio 30:2). After 2 min of routine CPR, one of the two technicians performed airway management with each of the six devices above in a computer-generated randomised sequence using ARandomizer software (https://www.muw.ac.at/randomizer/web/login.php) from the Medical University of Graz, again using the Resuscsi Anne Advanced Simulator. The manikin and the airway devices were wetted thoroughly with the lubricant recommended by Laerdal. Teams of participating technicians were evaluated alone and were not allowed to watch other teams.

Chest-compressions continued during airway management attempts and the technicians were asked to avoid stopping chest compressions, and therefore minimize hands-off time. In cases where the insertion of the airway was not possible during on-going chest compressions, the airway performing technician was advised to state “stop compressions” then complete insertion process and state “continue compressions” as soon as possible. When hands-off time exceeded 10 s, technicians were instructed to interpose bag-valve ventilation for at least 30 s (30:2 ratio of compressions to breaths).\textsuperscript{12} As many as three attempts at securing an airway were allowed with each device.

If incorrect positioning of the tested airway device was recognised by the technicians, reposition was allowed. Airway management procedure was considered complete following the decision of the technicians that airway management and ventilation of the manikin was successful during on-going chest compressions according to the technicians’ assessment.

If more than three attempts were required or there was an unrecognised esophageal intubation, airway management was stopped and defined as failure.

The primary outcome parameter was hands-off time, defined as the cumulative duration of CPR discontinuation during airway insertion.\textsuperscript{18} A discontinuity of chest compressions during airway management exceeding 1.5 s was considered to be the beginning of a hands-off period. We recorded cumulative hands-off time during each airway management episode, with no requirement that the episodes be contiguous.

We also recorded time to successful ventilation, beginning with picking up an airway device or laryngoscope and ending with the technician’s decision that the airway was secured or three failed attempts. The success rate for each airway insertion was determined by an investigator using the manikin’s software and provided an additional secondary outcome parameter for analysis. Data were recorded by investigators and the manikin’s computer.

2.2. Statistical analysis

Hands-off time, time to ventilation, the number of insertion attempts, and airway placement success were analysed using a mixed-effects model accounting for the repeated measurements in the participants and with pair-wise comparisons between the airway device groups. Correction for multiple testing was performed according to Sidak.\textsuperscript{19} Results are reported as means (95% confidence intervals). A $p$-value of less than 0.05 was considered statistically significant.

Based on the results of a previous study, we expected an average difference in hands-off time of approximately 30% between endotracheal intubation and supraglottic devices used in this study and a standard deviation of $\pm$30%. 40 emergency medical technicians were included to achieve a power of 90% with an alpha error of 0.05.\textsuperscript{20}

For descriptive statistics, Sigmaplot, Version 11.0 (Systat Software Inc., Chicago, IL, USA) was used. SPSS 18.0 (IBM, Somer, NY) was used for all other analysis.

3. Results

Forty emergency medical technicians (33 men and 7 women, age 26 ± 5 years) participated in this study. The results from one technician in the Combitube trial were excluded from analysis because the device was inserted with the cuffs blocked. Results from all 40 technicians were available for all other devices.

The hands-off time including all intubation attempts for airway management using an endotracheal tube was 48 (95% confidence interval: 43–53) s, whereas hands-off time for laryngeal tube was 8.4 (3.4–16.4) s, Combitube 10.0 (4.9–15.1) s, Easytube 11.4 (6.4–16.4) s, LMA 13.3 (8.2–18.3) s, and for the I-Gel 15.9 (10.8–20.9) s. Hands-off time was significantly slower with the endotracheal tube than with any of the other airway systems, none of which differed significantly from each other (Table 1).

The technicians inserted a conventional endotracheal tube in 22 of 40 attempts; however, 8 of these 22 insertions were unrecognised esophageal intubations. The overall success rate was thus only 14 in 40 attempts (35%). On average, 2.2 insertion attempts were necessary to successfully secure endotracheal intubation. Therefore, the number of insertion attempts was significantly greater using conventional endotracheal tube than with Combitube (1.2, $p < 0.001$), Easytube (1.3, $p < 0.001$), laryngeal tube (1.4,
p < 0.001), LMA (1.5, p < 0.001), but was not significantly greater than with the I-Gel (1.9, p = 0.549).

The most successful device during the initial insertion attempt was the Combitube, with 34 of 39 (87%) of the initial insertions proving successful. However, all six airway devices were successfully inserted by each emergency medical technician in the course of up to three attempts.

The longest time to ventilation was 76 (51–100) s using endotracheal tube, whereas the shortest time to ventilation was found for laryngeal tube [38 (23–53)] s. Others were in between—I-Gel: 39 (24–54) s; LMA: 66 (51–80) s; Combitube: 68 (53–83) s; and EasyTube: 70 (55–84) s (Table 1).

4. Discussion

The hands-off time required for endotracheal intubation by inexperienced medical technicians far exceeded guidelines; furthermore, only about half the technicians were able to insert a tube at all—and many of the inserted tubes were actually recognised esophageal intubations. That inexperienced personnel had difficulty with endotracheal intubation is hardly surprising since about 30 intubations are necessary to develop even moderate facility with the technique—and that under optimal operating room conditions.21 The importance of experience is illustrated by the fact that experienced physicians required less than 5 s of hands-off time to intubate the trachea in a previous manikin study.22

Intubation in out-of-hospital emergency settings is especially challenging and presumably even more training is required. Given the relative rarity of out-of-hospital intubation, it is likely that considerable time is required to develop the requisite skills. It is also likely that many emergency medical technicians will not perform enough intubations to maintain a high skill level with this difficult technique—perhaps explaining why hands-off time during field intubation by experienced paramedics was not substantially shorter than for our inexperienced medical technicians.23,18

Unsurprisingly, the success rate for endotracheal intubation in pre-hospital settings mainly depends on the operators’ skills and experience.6–11 But even in experienced hands, unrecognised esophageal intubation remains a non-trivial risk, especially in pre-hospital settings24—and is associated with a 95% mortality in children and an 80% mortality in adults.25,26 In our study, a full third of the tube placements in manikins were actually unrecognised esophageal intubations, a fraction that would be completely unacceptable in patients. Unfortunately, the high failure rate we observed is hardly unusual. In a prospective analysis of 103 pre-hospital endotracheal intubation by emergency medical technicians, for example, Sayre et al. found a failure rate of 50% and unrecognised esophageal/esophageal intubations in 3%.27 In another study by Nicholl et al. failure rate exceeded 65%, even though intubation was performed by well trained paramedics.28

Since it was entirely predictable that inexperienced technicians would have difficulty with endotracheal intubation, our major question was related to performance with various supraglottic airway management devices. All five systems we tested—Combitube, EasyTube, laryngeal tube, Laryngeal Mask Airway, and I-Gel—performed well. Every medical technician was able to successfully insert the devices, although up to three attempts were occasionally required. Furthermore, median hands-off times ranged from 8 to 16 s, differences which are probably not clinically important.

Our results are generally consistent with previous studies. In a manikin study, for example, 50 intensive care nurses inserted a laryngeal tube during CPR.29 As we did, the investigators found that a laryngeal tube could be inserted quickly and reliably. The LMA is an accepted alternative to endotracheal intubation, especially in situations when endotracheal intubation has failed.12 Our medical technicians found that the LMA and the I-Gel tended to rotate and to displace laterally during CPR as described by Gatward et al.22 Even though Gatward et al. found the I-Gel to be inserted fastest by medical doctors, this trial included technicians with no previous experience in advanced airway management.22 In a manikin study including 200 paramedics, Wiese et al. found that the use of I-Gel and laryngeal tube were comparably effective.30 Furthermore, the difference in our study between the fastest (laryngeal tube) and slowest supraglottic airway (I-Gel) of approximately 8 s was not clinically important.

A recent study by Lefranc¸ et al. reported a high success rate with few side effects in 760 pre-hospital patients using the Combitube.31 Bollig et al. reported, that success rates were higher and intubation was significantly faster with a Combitube than with an endotracheal tube.14 Others also concluded that the Combitube is a useful emergency airway device, especially for paramedics.32,33 The EasyTube similarly appears useful in the pre-hospital setting, even for personnel with minimal training.34,35

Although time to ventilation was comparable with endotracheal intubation, the Combitube, and the EasyTube (due to the inflation of two cuffs in the latter), differed significantly in respect to hands-off time which is of greater clinical importance.

An obvious limitation of our study is that participating emergency medical technicians worked with manikins instead of patients—although the manikins we used are among the best available for airway simulation.36,37 The advantage of using manikins is that we could use a cross-over design and thus provide similar airway conditions for each participant and, more importantly, for each airway device. Nevertheless, data obtained in any manikin studies need to be confirmed in patients.

In summary, our results support the recommendation of the European Resuscitation Council that endotracheal intubation should only be performed by experienced staff. But at least in manikins, even inexperienced medical technicians can use supraglottic airway devices with a high degree of success and little interruption of chest compressions during CPR. Success rates and hands-off times were similar with the Combitube, EasyTube, laryngeal tube, Laryngeal Mask Airway, and I-Gel. Each of these devices appear to be a reasonable emergency airway management strategy, even for inexperienced personnel.
Conflicts of interest
Michael Frass invented the Combitube and has received royalties from Covidien. None of the other authors has a personal financial interest in this research.

Acknowledgements
The authors would like to thank the Red Cross Burgenland, Austria for their support and the local government of Burgenland for their financial support of this study. Furthermore, we want to thank Roraco, for providing the respective manikins.

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