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Comparison of the airway access skills of prehospital staff in moving and stationary ambulance simulation: A randomized crossover study☆

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ABSTRACT

Objectives: We aimed to compare the procedural success and intervention durations regarding various airway access skills in moving and stationary ambulance simulations.

Material and methods: An ambulance simulator was used to simulate the moving ambulance environment, and a standard manikin was used for airway simulation. The study included 38 paramedics and paramedic students. In stationary and moving environments, a classical endotracheal intubation with a stylet, an intubation with a gum elastic bougie (GEB), a laryngeal mask airway (LMA), and a laryngeal tube (LT) were applied randomly. The cuff inflation duration, the duration until the first ventilation, and the intubation success were assessed.

Results: There was no difference in terms of success and intubation durations of the four methods in moving and stationary environments. In both environments, the LT and LMA were inserted most rapidly ($p < 0.001$). There was no difference in the intubation duration and the success among the supraglottic methods. In moving and stationary environments, the intubation with a classic stylet was faster than the intubation with a GEB. The use of a GEB did not increase the intubation success.

Conclusions: In this simulation study, the moving environment did not affect the duration or success of the endotracheal intubation. Supraglottic methods were applied more quickly in both moving and stationary environments. A GEB was used successfully by practioners with no previous experience; however, the duration of the intubation was longer.

1. Introduction

Opening the airway and maintaining it continuously before reaching the hospital is one of the most important technical skills in emergency medicine. Intubation can be performed by a staff with sufficient experience. A staff with insufficient experience in intubation must be familiar with alternative airway techniques. The selected alternative airway management technique should be easy to use, and the method should protect the patient from airway aspiration.[1] There is evidence that an appropriate and timely intubation affects mortality and morbidity. The supraglottic airway maintains standard airways. Studies in simulated clinical environments have obtained high success speeds versus endotracheal intubation.[2,3] In a surgical series, the reported success rates were between 44% and 100%.[4,5] Studies have reported that for airway management outside the hospital, supraglottic airway access methods are extremely successful.[6,7]

The European Resuscitation Council recommends supraglottic airway management techniques outside the hospital. However, the most appropriate method for use in patients in a moving ambulance remains unknown. Although endotracheal intubation (ETT) outside the hospital is slightly less successful than other methods, it is the gold standard. In a study comparing various airway management techniques applied to cases with a cardiac arrest outside the hospital, the survival rates of patients with ETT were slightly better than patients with other airway management techniques.[8]

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There are many studies evaluating various airway access methods both inside and outside the hospital. Studies evaluating intubation methods in an ambulance or a simulator are rare. A study by Gough et al. showed that paramedics could successfully complete ETT in a moving ambulance.[9] In contrast, when a patient requires an airway access outside the hospital, the ambulance is stopped and started again only after the airway is secured, which may delay patients from reaching in time for emergency services. As a result, we planned to complete a study assessing the airway skills of emergency medical personnel in the ambulance environment.

We compared various airway management techniques (LMA, LT, and endotracheal intubation with normal and gum elastic stylets) in moving and stationary ambulance simulations to test the hypothesis that choosing the correct airway management technique will allow a successful airway intervention in a moving ambulance. We proposed that ETT with a GEB could increase the possibility of success and would be as easy to apply as supraglottic methods. The criteria for success were the duration until sufficient respiration, a cuff inflation and first respiration, and the number of attempts. In addition, the practitioners were asked about their perception of ease or difficulty of the methods in both environments.

2. Materials and methods

This study was planned as a methodological and randomized crossover study. Following the grant of permission by the Dokuz Eylul University Medical Faculty Research Ethics Committee, the study began in March 2014.

2.1. Research sampling

The study population included paramedics actively working with the Izmir 112 Provincial Ambulance Service as well as paramedic students. A sufficient number of individuals participated in order to fulfill the previously determined sampling number.

In a study carried out on 121 Turkish paramedic students, Cinar et al. reported successful airway provision rates of 78.5% using a Macintosh laryngoscope.[10] Using this data, we calculated that a sample size of 30 is required to determine a 20% difference in airway provision devices with an alpha error of 0.5 and power of 80%. Four methods were selected at random by selecting envelopes describing the intervention in moving or stationary environments.

2.2. Ambulance environment simulation

The Simsoft Computer Technologies (Ankara, Turkey) ambulance simulator was used, which is a full-size ambulance that can simulate airway conditions as well as vibrations in the ambulance and driver use, controlled by computer software, in order to reproduce the ambulance environment in standard road and normal weather conditions. Before each use, the standard road choice and weather conditions are set and operated by a driver each time. This program allows the driver to follow the road visually. The ambulance is set to allow only the use of the fourth gear after the third gear. The individual drives the ambulance by visually tracking the road on three projectors mounted on the ambulance.

The cameras within the simulator monitor interventions in the back of the ambulance, which allows the director operating the main command system of the ambulance simulation to observe two different camera images simultaneously.

Inside the ambulance, an advanced cardiac life support manikin allowing airway intervention was placed on a trolley for patient simulation (Deluxe CRiSis™ Manikin — LF03955U. Wisconsin. USA, Fig. 1). A sufficient tidal volume ventilation value for this manikin was set to 0.8 L, and this was monitored from outside the ambulance. After intubation, successful ventilation was assessed by monitoring this metrically.

2.3. The training of practitioners

Before the study, 38 paramedics were given theoretical and practical training in all airway management techniques on two different days. After a 45-minute classic presentation, each practitioner completed each intervention three times. Each application was recorded, and a successful completion of 12 intubations was documented. In addition, the paramedics participating in the study were informed of the study method.

2.4. The airway material used

1. An intubation tube No: 7.5
2. An laryngeal tube (LT) No: 3 (VBM Medizintechnik, Sulz, Germany)
3. An laryngeal mask airway (LMA) Supreme® Size 3 (Hangzhou Fushan Medical Appliances Co., Ltd. Lin'an City Zhejiang, China)
4. A standard Macintosh laryngoscope, blade 3
5. An gum elastic bougie (GEB) ([AMTI15750] Armstrong Medical Ltd, Coleraine, Northern Ireland)

2.5. The airway interventions applied

1. A standard Macintosh laryngoscope and classic stylet
2. A standard Macintosh laryngoscope and GEB (Before each intubation, the GEB was prepared by inserting it into the intubation tube)
3. An laryngeal mask application
4. An LT application

2.6. An assessment

To prevent a bias based on the previous experience and skills of the paramedics participating in the study related to the airway management techniques, the airway management technique to be applied was determined at random by choosing four envelopes. Before this, four envelopes containing each of the four airway management techniques were prepared. The order of the envelopes determined the order of the methods.

In general, one driver and two health personnel work in ambulances in Turkey. Permission was granted for an assistant to be present during the application because there is always an assistant in the ambulance environment. The assistant only gave the requested tube to the practitioner.

A study team watching the camera images outside the ambulance assessed the progress. One of the cameras was positioned in order to assess the patient's airway and chest and the other showed the ambulance team.

2.7. The intubation success

When an endotracheal tube (ET) is inserted into the oropharynx, it was defined as an intubation attempt. The intervention was

Fig. 1. Outer appearance of simulator ambulance, position of the manikin and outer command center.

considered unsuccessful after three failed attempts. For resuscitation within the ambulance, each practitioner began the respiration with a balloon valve mask (BVM) before each airway intervention. After this, at least three respiration interventions occurred when one of the assessors gave the order to start. If success could not be achieved within 60 s, then the attempt was ended. Another attempt was made after the manikin was again respirated with a BVM. If the third attempt at airway intervention was not successful, then the intervention with this method was considered unsuccessful. Time measurements were recorded with a standard chronometer (a Casio Hs-80Tw-1Df chronometer).

2.8. The assessment parameters

2.8.1. For endotracheal intubation and intubation with a GEB

1. The time for an endotacheal tube passing through the cord (The practitioner loudly stated that the vocal cord was passed through using the ET)
2. The time that passed until the cuff was inflated (the time until the cuff inflation)
3. The time until the first ventilation

2.8.2. For a supraglottic airway

1. The time that passed until the cuff was inflated
2. The time for the initiation of the first ventilation

A 10 cm visual analog scale was used to assess the ease of application. The evaluation was made by measuring the scale with a ruler.

2.9. The statistical analysis

The data were recorded on the previously prepared "Study Data Form," and Statistical Package for Social Sciences for Windows 19.0 software was used for the analysis. Normal distributions of numerical variables were tested with the Kolmogorov Smirnov Test. Numerical variables between two independent groups were compared using the Student's t-test for normally distributed data and the Mann-Whitney *U* test for data without a normal distribution. The Wilcoxon rank test was used to compare the groups in different environments. One-way ANOVA testing was used for multi-group comparisons. The categorical results related to intubation success were evaluated with the chi square test. The results are given as the mean ± standard deviation. $p < 0.05$ was

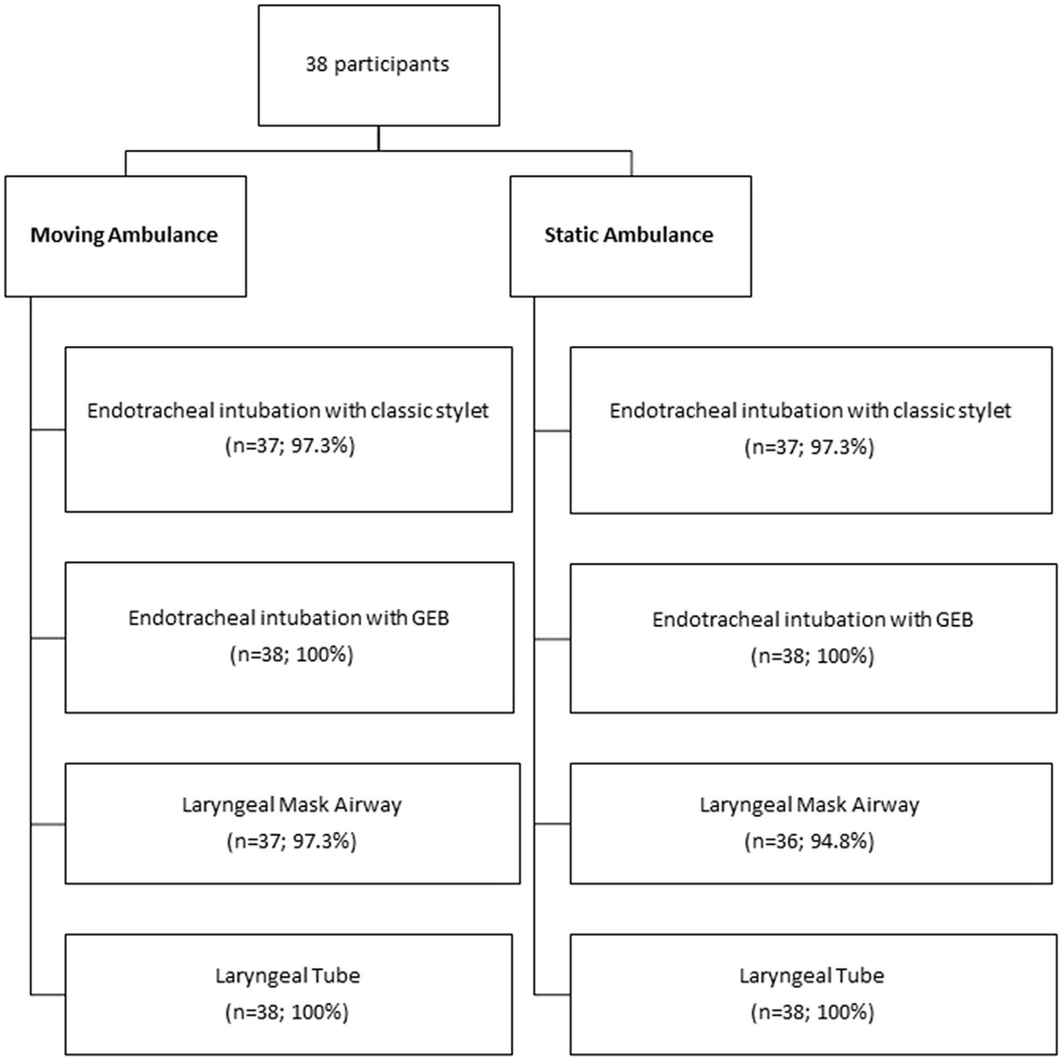

Fig. 2. Flowchart of the experiment and the success numbers of interventions.

considered to be significant.

3. Results

A total of 38 people participated in the study. Three of the practitioners were active paramedics working in the Izmir 112 Provincial Ambulance Service with 38 practitioners chosen from among students at the Dokuz Eylul University, Vocational School of Health Services, First and Emergency Aid Program; 29 participants were female.

3.1. The comparison of success of the airway intervention

In moving and stationary ambulance simulation, 38 practitioners completed intubation attempts using four different methods. Five intubation interventions were unsuccessful: two were in the stationary environment and three were in the moving environment. The most frequent unsuccessful intubation intervention occurred with the LMA: one in the stationary and two while moving for a total of three times (Fig. 2). There was no difference in the success rates between moving and stationary ambulance simulations (Table 1).

3.2. The comparison of the duration of interventions

The duration of the infraglottic methods to pass the vocal cords was studied. In both environments, classic intubation with a Macintosh laryngoscope achieved success more quickly. The duration to pass the vocal cords with the GEB did not surpass 30 s. In the moving ambulance, the duration to pass the vocal cords of practitioners during intubation with the GEB was reduced. There was no statistically significant difference in the time for ETT to pass through the cord with a classic stylet and the GEB ($p > 0.05$ for both).

When the time passed until the cuff inflation by the intubation methods used in our study were examined, the longest time was found for the intubation with the GEB in both environments. The LT was the shortest method for a successful cuff inflation by the practitioners in both moving and stationary ambulance simulations. There were no statistically significant differences found between the times of cuff inflation of all of the methods in both of the environments.

The longest time for the initiation of the first ventilation was found for a GEB intubation in both environments. LT in both moving and stationary settings had the shortest time for the initiation of the first ventilation. All of the intubation methods have shorter

Table 1
Comparison of success of all methods and duration of the intubation in moving and stationary ambulance simulations.

Method	Stationary Environment			Moving Environment			P value
	Time until the cuff inflation (s)	Time until the first ventilation (s)	Success (%)	Time until the cuff inflation (s)	Time until the first ventilation (s)	Success (%)	
ETT with Classic Stylet	13.2 ± 5.9	18.1 ± 7.1	37 (97.3%)	12.5 ± 6.6	16.65 ± 7.9	37 (97.3%)	>0.05
ETT with GEB	16.6 ± 5.7	20.8 ± 7.0	38 (100%)	16.1 ± 6.7	20.34 ± 7.9	38 (100%)	>0.05
LMA	6.6 ± 2.4	10.9 ± 6.2	37 (97.3%)	6.2 ± 1.8	9.53 ± 3.7	36 (94.8%)	>0.05
LT	6.3 ± 2.4	10.4 ± 3.8	38 (100%)	5.5 ± 1.5	9.32 ± 3.6	38 (100%)	>0.05
Comparison of use of infraglottic/supraglottic methods							
All infraglottic methods		19.4 ± 7.1	75 (98.7%)		18.5 ± 8.0	75 (98.7%)	
All supraglottic methods		10.5 ± 5.0	75 (98.7%)		9.4 ± 3.6	74 (97.4%)	
P value		**p < 0.001**	p>0.05		**p < 0.001**	p>0.05	

GEB: gum elastic bougie; LMA: laryngeal mask airway; LT: laryngeal tube; s: second.
Bold: Statistically significant values.

durations until the cuff inflation and the first ventilation in the moving environment. The practitioners achieved success with the classic intubation using a Macintosh laryngoscope and a classic stylet in a longer time interval than the other methods. There were no statistically significant differences found between the times for the initiation of the first ventilation in the moving and stationary ambulance simulations ($p > 0.05$).

When the number of attempts, the time required to pass the vocal cords, the cuff inflation duration, and the first ventilation duration steps were examined for infraglottic methods in moving and stationary ambulance simulations, there was no statistically significant difference found between the number of attempts in moving and stationary ambulances ($p > 0.05$). In the stationary environment, there was a statistically significant difference in the duration to pass the vocal cords between the intubation using a Macintosh laryngoscope and a classic stylet and a GEB ($p < 0.001$). There was a significant difference in the cuff inflation duration ($p < 0.05$) in both environments. In a moving ambulance, there was a statistically significant difference between the duration until the first ventilation ($p < 0.05$) (Table 2).

There was no significant difference in the number of attempts and durations to the cuff inflation or the first ventilation in the stationary environment between the LMA and the LT ($p = 0.132$, $p = 0.619$, and $p = 0.676$, respectively). Between the LMA and the LT in the moving environment, there was no significant difference in the number of attempts and the duration until the cuff inflation and the first ventilation ($p > 0.05$ for all). We compared the supraglottic and infraglottic methods in moving and stationary environments with the Wilcoxon Rank test. There was no difference in terms of success, but the supraglottic methods aided significantly quicker insertion ($p < 0.001$) (Table 1).

3.3. A comparison of the ease of procedure

The perception of ease of use was assessed in both environments and LT was considered to have the easiest application. Use of GEB did not ease the application in moving or stationary environments (Table 3).

4. Discussion

This study compared different intubation methods in moving and stationary ambulance environments. The supraglottic methods were applied faster in both, but there was no difference observed in terms of success. While one might think that a moving ambulance would affect the success rates, we found no difference between the moving and stationary conditions. This was true for both the success rate and the duration of the procedure.

The use of supraglottic methods outside the hospital varies depending on the country. In Turkey, the LMA is an alternative airway management technique frequently used in ambulances. In the USA, the most frequently used methods are combitube and LT. The LT is the most successfully applied method among supraglottic methods for airway management.[11] Wahlen et al. studied endotracheal intubation and six different supraglottic airway devices, comparing the success of health workers with varying levels of experience in accessing the airway of a manikin. Although the anesthetists were the ones to complete the endotracheal intubation the quickest, experience did not play a role in the success rate for the insertion of a classic LMA, a proseal LMA, an LT, and an esophageal combitube.[12] In our study, the laryngeal tube (LT) was inserted in the first attempt by all the practitioners participating in the study. An LT comes to the fore among supraglottic airway devices. Trabold et al. compared the use of a combitube, an easytube, and a LT on a manikin in terms of success and speed of insertion. They found that the LT was the most successful method.[13] Studies comparing it to an LMA found that LT is employed more quickly and successfully.[14]

We found no difference in terms of the durations and success of supraglottic methods. The moving environment did not change the success or duration of application of both the supraglottic methods. Endotracheal intubation is a skilled intervention. There are differences in the rates of application outside the hospital. The success rate outside the hospital is in the range of 77%–85%. The success of the application is related to the training of the practitioner; however, other factors that affect success are important.[15] For example, it is known that a rapid sequential intubation of critical patients changes the results. A study in Germany determined the intubation success of paramedics as 46.4%, but the success rate is 99% in the USA[16] and 78% in Israel.[17] Manikin studies have showed variable results. Keier et al. studied 56 paramedic students in sequential classes over 3 years. They found that 30.4% of the intubations were completed outside the hospital for a total of 1616 intubations with a first attempt success of 66%. The mean intubation success was 88%.[17] The success rate was affected by situations such as the educational level of the paramedic and skill in rapid sequential intubation applications. In our study, paramedics and paramedic students had a 97.3% success rate. The success rate in our study may

Table 2
Assessment of procedural stages of infraglottic methods in moving and stationary environments.

		ETT with Classic Stylet	ETT with GEB	P
		Mean ± SD	Mean ± SD	
Number of attempts	Static	1.18 ± 0.46	1.26 ± 0.50	0.476
	Moving	1.32 ± 0.66	1.13 ± 0.48	0.168
The time for an ET passing through the cord	Static	8.43 ± 3.33	12.55 ± 5.20	<**0.001**
	Moving	9.57 ± 6.09	12.08 ± 5.87	0.073
The time until the cuff inflation	Static	13.16 ± 5.86	16.58 ± 5.73	**0.013**
	Moving	12.54 ± 6.64	16.08 ± 6.65	**0.024**
The time until the first ventilation	Static	18.14 ± 7.11	20.79 ± 7.03	0.108
	Moving	16.65 ± 7.87	20.34 ± 7.90	**0.046**

Bold: Statistically significant values.

Table 3
Assessment of ease of procedure.

	ETT with Classic Stylet		ETT with GEB		LMA		LT	
	Static n (%)	Moving n (%)	Static n (%)	Moving n (%)	Static n (%)	Moving n (%)	Static n (%)	Moving n (%)
1	14 (36.8)	9 (23.7)	13 (34.2)	8 (21.1)	18 (47.4)	11 (28.9)	19 (50)	15 (39.5)
2	10 (26.3)	11 (28.9)	8 (21.1)	7 (18.4)	9 (23.7)	11 (28.9)	9 (23.7)	9 (23.7)
3	8 (21.1)	12 (31.6)	11 (28.9)	15 (39.5)	4 (10.5)	8 (21.1)	3 (7.9)	9 (23.7)
4	6 (15.8)	3 (7.9)	5 (13.2)	5 (13.2)	5 (13.2)	8 (21.1)	4 (10.5)	2 (5.3)
5		3 (7.9)	1 (2.6)	2 (5.3)	2 (5.3)	0	3 (7.9)	3 (7.9)
6	0	0	0	1 (2.6)	0	0	0	0
7-10	0	0	0	0	0	0	0	0

In scale of 1–10. (1: very easy procedure; 10: very difficult procedure).
GEB: gum elastic bougie; LMA: laryngeal mask airway; LT: laryngeal tube.

be higher than that reported in the literature due to the airway model used or the use of a lifeless manikin. The results may be different for a more complicated airway model or actual patients.

The GEB is an introducer for intubations, and it is an alternative airway management technique for difficult situations. Difficult airways may be successfully applied outside the hospital.[18–20] The Joint Royal Colleges Ambulance Liaison Committee in the UK announced the necessity of having a GEB in ambulances for intubation.[21] This study tested the hypothesis that it would ease intubation in moving environments. In our study, all of the intubations with a GEB were successfully completed, while only two intubations were unsuccessful for intubations using a classic stylet. We found that the use of a GEB in the moving environment did not contribute positively to the ease of application but that it clearly lengthened the duration of intubation. While our practitioners had no experience with a GEB, they easily utilized this tool. This result is similar to that of Gregory et al. on paramedics and difficult airways.[22]

Contrary to expectations, we found that airway interventions in a moving environment were completed more quickly. However, there were no statistically significant differences in the duration of interventions in both environments. There are very few studies involving moving ambulance environments in the literature. We are not aware of any study completed in an ambulance simulator. Interestingly, Wong et al. found that difficult airway interventions were completed in a shorter time in a moving environment than in a normal airway.[23] We think that these unexpected results may be due to the practitioners using the methods on manikins consecutively. In our study, the order of application of airway interventions was randomly determined; however, all of the interventions were completed sequentially. The interventions were first completed in the stationary ambulance and then in a moving simulator, which increased the experience of the practitioners. As a result, we think that the latter interventions became easier.

Voscopoulos et al. compared different supraglottic methods used by emergency medical technicians and found that LMA and LT were successful and rapidly applied.[24] This study did not initially observe any difference between the two methods. Muller et al. monitored uses of LT for cardiac arrest outside of the hospital. There were 57 successful interventions completed in under 10 s, 58 in 10–20 s, 8 in 21–30 s and 7 over 30 s.[25] Similar to LT, in our study, the mean duration in the moving environment was 9.4 s and 10.5 s in the stationary environment. The practitioners stated that LT was the easiest device to use. LT can be rapidly and effectively used in moving and stationary environments even by inexperienced individuals.

4.1. Limitations

Our study used a simulator to reproduce the ambulance environment. It is not the same as the real environment no matter how closely the movement and visual environment of the simulator recreated reality. In a real ambulance, differences exist due to road conditions and the use of vehicle.

The airway interventions were performed on a standard lifeless manikin. While standard airway conditions can be accurately recreated in manikin studies, there are clear differences versus the airways of live models and real patients. In practice, complications such as vomiting, hemorrhage, airway obstruction, and masses are observed in airway interventions. In addition, applications outside the hospital are hampered by psychological effects created by movement and the stressful environment, which is difficult to recreate. In addition, complications linked to the intervention were not assessed by this study. In conclusion, the conditions in this study only simulate real life, and the results may be different from real situations.

5. Conclusions

The moving environment did not affect the duration or success of an endotracheal intubation. The GEB was successfully used by practitioners with no previous experience; however, the duration of the intubation was longer. The results of this study show that all airway management techniques can be effectively used in a moving environment before the patient reaches the hospital. We believe that new studies are required to assess these findings in a real ambulance.

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7. Conflict of interest

Throughout the study, no material and/or moral support, which can negatively affect the decision to be made about the study during the evaluation process, was obtained from any firm or any business firm that provides and/or manufactures any medical tools, equipment or materials that are directly related to the research topic.

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References

1. Schalk R, Byhahn C, Fausel F, et al. Out-of-hospital airway management by paramedics and emergency physicians using laryngeal tubes. *Resuscitation*. 2010;81:323–326.
2. Jokel J, Nurmi J, Genzwuerker HV, Castrén M. Laryngeal tube and intubating laryngeal mask insertion in a manikin by first-responder trainees after a short video-clip demonstration. *Prehosp Disaster Med*. 2009 Jan-Feb;24(1):63–66.
3. Tumpach EA, Lutes M, Ford D. The King LT versus the Combitube: flight crew performance and preference. *Prehosp Emerg Care*. 2009 Jul-Sep;13(3):324–328.
4. Kurola JO, Turunen MJ, Laasko JP, Gorski JT, Paakkonen HJ, Silfvast TO. A comparison of the laryngeal tube and bag-valve mask ventilation by emergency medical technicians: a feasibility study in anesthetized patients. *Anesth Analg*. 2005 Nov;101(5):1477–1481.
5. Kurola J, Pere P, Niemi-Murola L, et al. Comparison of airway management with the intubating laryngeal mask, laryngeal tube and Cobra PLA by paramedical students in anaesthetized patients. *Acta Anaesthesiol Scand*. 2006;50:40–44.
6. Wiese CH, Semmel T, Müller JU, Bahr J, Ocker H, Graf BM. The use of the laryngeal tube disposable (LT-D) by paramedics during out-of-hospital resuscitation, an observational study concerning ERC guidelines 2005. *Resuscitation*. 2009 Feb;80(2):194–198.
7. Frascone RJ, Wewerka SS, Griffith KR, Salzman JG. Use of the King LTS-D during medication-assisted airway management. *Prehosp Emerg Care*. 2009;13:541–545.
8. Wang HE, Szydlo D, Stouffer JA, Lin S, et al. Endotracheal intubation versus supraglottic airway insertion in out-of hospital cardiac arrest. *Resuscitation*. 2012 Sep;83(9):1061–1066.
9. Gough JE, Thomas SH, Brown LH, Reese JE, Stone CK. Does the ambulance environment adversely affect the ability to perform oral endotracheal intubation? *Prehosp Disaster Med*. 1996 Apr-Jun;11(2):141–143.
10. Cinar O, Cevik E, Yildirim AO, Yasar M, Kilic E, Comert B. Comparison of GlideScope video laryngoscope and intubating laryngeal mask airway with direct laryngoscopy for endotracheal intubation. *Eur J Emerg Med*. 2011 Apr;18(2):117–120.
11. Diggs LA, Yusuf JEW, De Leo G. An update on out-of-hospital airway management practices in the United States. *Resuscitation*. 2014;85(7):885–892.
12. Wahlen BM, Roewer N, Lange M, Kranke P. Tracheal intbation and alternative airway management devices used by healthcare professionals with different level of pre-existing skills: a manikin study. *Anaesthesia*. 2009;64(5):549–554.
13. Trabold B, Schmidt C, Schneider B, Akyol D, Gutsche M. Application of three airway devices during emergency medical training by health care providers a minikin study. *Am J Emerg Med*. 2008;26(7):783–788.
14. Wiese CH, Bahr J, Graf BM. Laryngeal tube-D" (LT-D) and "laryngeal mask" (LMA). *Dtsch Med Wochenschr*. 2009 Jan;134(3):69–74.
15. Prekker ME, Kwok H, Shin J, et al. First-pass intubation success rate during rapid sequence induction of prehospital anaesthesia by physicians versus paramedics. *Eur J Emerg Med*. 2015 Dec;22(6):391–394.
16. Katzenell U, Lipsky AM, Abramovich A, et al. Prehospital intubation success rates among Israel Defense Forces providers: epidemiologic analysis and effect on doctrine. *J Trauma Acute Care Surg*. 2013 Aug;75(Suppl 2):S178–S183.
17. Warner KJ, Carlbom D, Cooke CR, Bulger EM, Copass MK, Sharar SR. Paramedic training for proficient prehospital endotracheal intubation. *Prehosp Emerg Care*. 2010 Jan-Mar;14(1):103–108.
18. Combes X, Soupizet F, Jabre P, Margenet A, Marty J. Out of hospital difficult intubation resolved with nasotracheal use of a gum elastic bougie. *Emerg Med J*. 2006 Aug;23(8):e46.
19. Jabre P, Combes X, Leroux B, et al. Use of gum elastic bougie for prehospital difficult intubation. *Am J Emerg Med*. 2005 Jul;23(4):552–555.
20. Kovacs G, Law JA, McCrossin C, Vu M, Leblanc D, Gao J. A comparison of a fiberoptic stylet and a bougie as adjuncts to direct laryngoscopy in a manikin-simulated difficult airway. *Ann Emerg Med*. 2007 Dec;50(6):676–685.
21. Combes X, Jabre P, Margenet A, Merle JC, et al. Unanticipated difficult airway management in the prehospital emergency setting: prospective validation of an algorithm. *Anesthesiology*. 2011 Jan;114(1):105–110.
22. Gregory P, Woollard M, Lighton D, et al. Comparison of malleable stylet and reusable and disposable bougies by paramedics in a simulated difficult intubation. *Anaesthesia*. 2012 Apr;67(4):371–376.
23. Wong KB, Lui CT, Chan WY, Lau TL, Tang SY, Tsui KL. Comparison of different intubation techniques performed inside a moving ambulance: a manikin study. *Hong Kong Med J*. 2014 Aug;20(4):304–312.
24. Voscopoulos C, Barker T, Listwa T, et al. A comparison of the speed, success rate, and retention of rescue airway devices placed by first-responder emergency medical technicians: a high-fidelity human patient simulation study. *J Emerg Med*. 2013 Apr;44(4):784–789.
25. Müller JU, Semmel T, Stepan R, et al. The use of the laryngeal tube disposable by paramedics during out-of-hospital cardiac arrest: a prospectively observational study (2008–2012). *Emerg Med J*. 2013 Dec;30(12):1012–1016.