

A Simulation Study of Prehospital Airway using Mannequins: A Comparison of E.T Tube, L.M.A Classic, S.A.L.T

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Abstract

Background/Objectives: This study aims to evaluate usefulness of different airway devices by comparative analyzing intubation success rate and conduct time in the ambulance while driving and in indoor using mannequins. **Methods/Statistical Analysis:** It was conducted by placing three mannequins to floor of desk with height of patients' bed while 1 emergency rescue professor and 1 fire fighter stand in front of 1 student who participates in assessment and 1 student who assists the assessment standing in front of each mannequin. Upon completion of first assessment, intubation practice taking place during the transfer was conducted with the use of ambulance. **Findings:** The result from the indoor performance demonstrates that intubation success rate except for the intubation conduct time and the total conduct time are comparable statistically. However, the result from the performance in the ambulance while driving shows a statistically significant difference in intubation success rate, the intubation conduct time, and the total conduct time. In addition, the preference survey of airway devices conducted by 60 participants of this study shows LMA-Classic is the most preferred. **Application/Improvements:** It was study which conducts comparative experiment only on airway devices such as three devices, it is proposed that comparative study with various airway devices and others shall be conducted.

Keywords: Endotracheal Tube, Intubation, Laryngeal Mask Airway, Supra-glottic Airway Laryngopharyngeal Tube

1. Introduction

Proper airway maintenance and respiratory treatment of pre-hospital stage is crucial for life maintenance of emergency patients and important for positive prognosis of patient as well. The guidelines for emergency medical technicians also designate legal range of emergency treatment for airway maintenance and respiratory treatment and endotracheal and laryngeal mask intubation for airway maintenance and respiratory treatment are permitted to domestic grade 1 emergency medical technicians¹. However, there is not a single case of endotracheal intubation among 515 patients who were transferred

from 9 emergency medical institutions to hospital via 119 ambulance for 2 months during². Also, according to 2014 nationwide rescue and emergency activity statistics conducted by MPSS, the number of patients who received endotracheal and laryngeal mask intubation from 603,874 dispatches which required airway maintenance and respiratory treatment among 1,631,724 patients transferred via 119 ambulance in a year was mere 840 and 1,269 respectively presenting 0.1% and 0.2% of total airway maintenance and respiratory treatment cases³. Considering the importance of adequate and prompt airway maintenance and respiratory treatment to emergency patients of pre-hospital stage, the current

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rate of endotracheal intubation conducted to patients is absolutely low. However, since it is difficult to properly conduct endotracheal intubation during emergency treatment of pre-hospital stage⁴ and there is high possibility for not only side effect followed by intubation failure but also cause of civil complaint occurrence followed intubation failure in regards to 119 emergency rescuer who in charge of transfer from the site to hospital, it is difficult to expect the increase in rate of endotracheal intubation under current circumstances. Therefore, in order to promote more accurate and convenient onsite airway maintenance, more spotlight has been shed upon airway devices and various easy-to-use tools have been developed. However, there is lack of studies that coincide with current circumstances of Korea. Therefore, authors have conducted mannequin simulation using Endotracheal Tube (ET tube) and Laryngeal Mask Airway (LMA-Classic) placed upon nationwide ambulance and Supra-glottic Airway Laryngopharyngeal Tube (SALT) which has not been introduced yet in Korea. Then comparative analysis on intubation success rate and operating time for each airway devices was conducted to examine the feasibility of each device.

2. Research Method

2.1 Subject

The size of sample for this study was 51 when the calculation was conducted using G*power 3.0 program with effect size 0.5, significance level $\alpha = .05$, and statistical power 80% with emergency rescue major students in D university located in D city as its subject. Considering the failure rate of 10%, 60 people who understood the purpose of research and agreed to participate were selected as the subject. All subjects completed the process of understanding and practicing the skill through regular courses and practice on endotracheal and laryngeal mask intubation.

2.2 Research Method

This research was conducted in D university located in D city from May 7th to May 9th, 2014 and lecture on three types of airway devices was given for 30 minutes with 60 research subjects as its target. Then, the subjects

were divided into 6 groups for education and practice on the usage of three airway devices which were conducted within each group for 60 minutes using the mannequin. The instructors in charge of education were 3 emergency rescue professors and 3 grade 1 emergency medical technicians currently working as fire fighter. Instructors gathered together to share their knowledge on three types of airway devices through pre-meeting and conducted 2 hour practice run using mannequin. 3 laryngoscope blade of different sizes, 1 handle, 1 stylet, 1 20CC syringe, and 6 airways of different sizes were prepared for endotracheal intubation. ET tube of 7.5 mm sold by Unomedical was used and LMA-Classic size no.4 (50~70kg) was used for laryngeal mask. In regards to SALT, size no.4, generally used for normal adult, was used as well. Airway Management Trainer Manikin (Adult) of Laerdal (Laerdal Medical Corporation, Stavanger, Norway) was used for practice. It was examined in advance that there is no difference in result based on mannequin. In regards to research method, it was conducted by placing three mannequins to floor of desk with height of patients' bed while 1 emergency rescue professor and 1 fire fighter stand in front of 1 student who participates in assessment and 1 student who assists the assessment standing in front of each mannequin. Upon completion of first assessment, intubation practice taking place during the transfer was conducted with the use of ambulance. It was conducted under the assumption that intubation is conducted during the transfer of patients from the site to hospital. The same assessment was conducted by an instructor with 1 student participating in the assessment and 1 student helping the assessment while placing a mannequin to the stretcher in actually operating ambulance which runs the same distance. In regards to scenario, the subject was patient without consciousness and breath and ventilation was conducted after the intubation of airway devices after examining the initial response of virtual patient, the mannequin. Unified standard was established among research team through in-advance meeting and performance items of national examination for grade 1 emergency medical technician adopted as a result. The success of intubation was determined by the lift of mannequin's lung at the moment of ventilation after the intubation and it was considered as failure when no lift is exhibited. Also, it was considered as a failure when successful intubation cannot

be conducted within 30 sec of ventilation suspension. It was considered as a success if the duration of entire procedure does not exceed 1 min when another opportunity was given after re-ventilation in case of failure in the first attempt.

2.3 Analysis Method

SPSS for Window 21.0 program (SPSS INC., Chicago, IL, USA) was used for statistics and general traits were extracted with the use of descriptive statistics. In regards to statistical difference of each airway device after examining normal distribution of data, it was analyzed through One-way ANOVA test and statistical significance was placed only when p value is 0.05 or lower.

3. Results

3.1 General Trait of Subject

Total number of subjects participated in this research was 60 with 22 male participants (36.7%) and 38 female

participants (63.3%) and average age of participants was 21.1 ± 1.3 . In case of ET tube and LMA-Classic among airway devices, all trainees had the experience of receiving one or more training before this session. In case of SALT, only 3 received training before this experiment. Excluding 2 trainees who have experience of applying LMA-Classic once or more to actual patients, no one had actual experience of using ET tube and SALT (Table 1).

3.2 Intubation Success Rate and Time for Each Airway Device (Indoor)

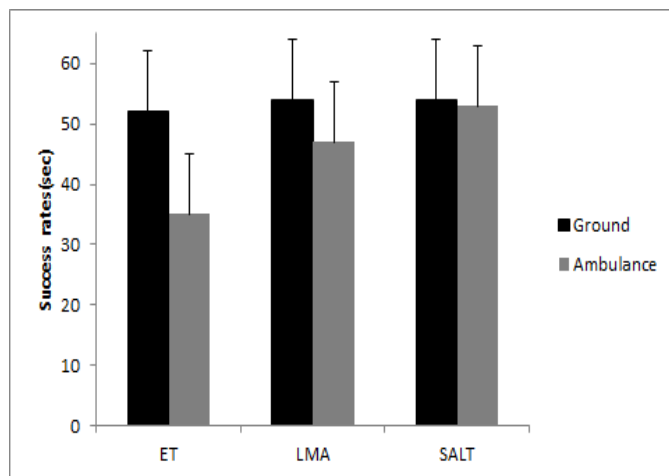
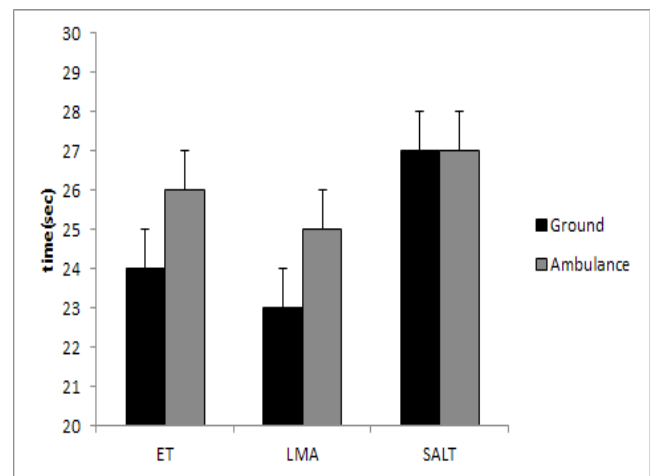
The indoor conducted intubation success rate of each airway device was 86.67% in case of ET tube, 90.00% for LMA-Classic, and 90.00% for SALT. Although the success rate of LMA-Classic and SALT was higher than that of ET tube, there was no statistically significant difference between each group ($p=0.801$). In regards to time spent on securing airway, it was 24.42 sec for ET tube, 23.72 sec for LMA-Classic, and 27.22 sec for SALT presenting statistically significant difference between each group

Table 1. Demographic characteristics of subjects

Gender, N(%)		Age(mean \pm SD)
Male	22(33.7)	21.1 \pm 1.3
Female	38(63.3)	
Prior educational experience, N(%)	Yes	No
ET tube	60(100)	0(0)
LMA Classic	60(100)	0(0)
SALT	3(5)	57(95)
Prior experience in using each device, N (%)	Yes	No
ET tube	0(0)	60(100)
LMA Classic	2(3.3)	58(96.7)
SALT	0(0)	60(100)

Table 2. Success rate and intubation time of each airway device (indoor)

Success rate, N(%)	Yes	No	p-value
ET tube	52(86.6)	8(13.4)	0.801
LMA Classic	54(90.0)	6(10.0)	
SALT	54(90.0)	6(10.0)	
The time taken to intubate (sec)			
ET tube	24.4±4.9		0.000*
LMA Classic	23.7±4.8		
SALT	27.2±5.2		
The total conduct time (sec)			
ET tube	33.3±5.7		0.303
LMA Classic	29.6±5.4		
SALT	32.0±5.6		

**(a)****(b)**

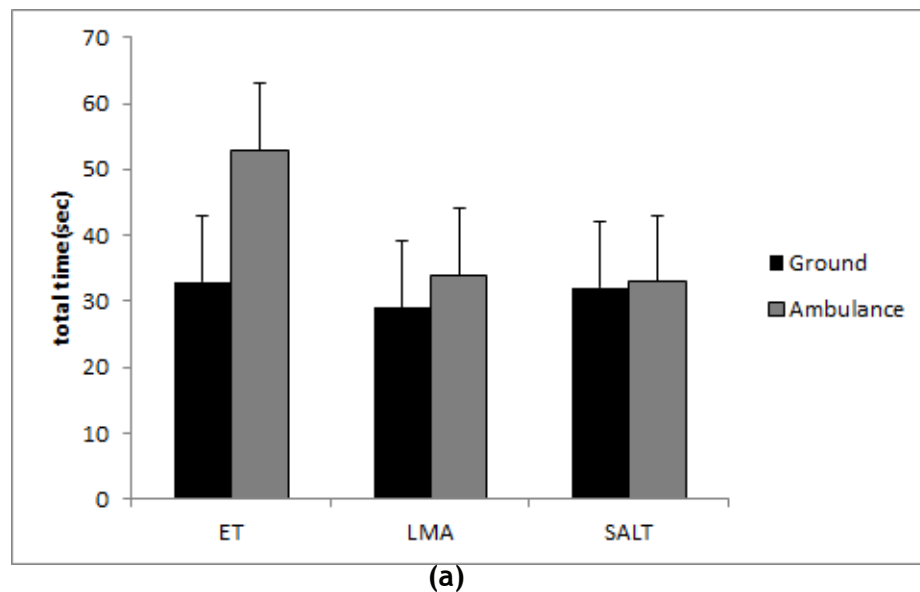


Figure 1. The results of each airway device. (a) The success rate of each airway device, (b) The intubation time of each airway device, (c) The total conduct time of each airway device.

($p=0.000$) but there was no statistically significant difference in total performance time presenting 33.38 sec, 29.68 sec, and 32.02 sec respectively ($p=0.303$) (Table 2) (Figure 1).

3.3 Intubation Success Rate and Time for Each Airway Device (inside Ambulance)

The success rate of airway device intubation conducted within ambulance was 58.33% for ET tube, 78.33% for

Table 3. Success rate and intubation time of each airway device (in-ambulance)

Success rate, N(%)	Yes	No	p-value
ET tube	35(58.3)	25(41.7)	0.000*
LMA Classic	47(78.3)	13(21.7)	
SALT	53(88.3)	7(11.7)	
The time taken to intubate (sec)			
ET tube	26.7±5.1		0.000*
LMA Classic	25.5±5.0		
SALT	27.5±5.2		
The total conduct time (sec)			
ET tube	53.0±7.2		0.000*
LMA Classic	34.8±5.9		
SALT	33.0±5.7		

LMA-Classic and 88.33% for SALT thus the success rate of SALT was the highest and that of ET Tube the lowest. Also, there was statistically significant difference between each group ($p=0.000$). In regards to the time spend to secure airway, it was 26.78 sec for ET tube, 25.57 sec for LMA-Classic, and 27.55 sec for SALT presenting statistically significant difference between each group ($p=0.000$) and total performance time also presented statistically significant difference between each group with 53.03 sec, 34.88 sec, and 33.02 sec respectively ($p=0.000$) (Table 3) (Figure 1).

3.4 Preference

In regards to preference survey on each tool conducted with trainee upon completion of training, there was statistically significant difference between each group presenting ET tube 6.67 %, LMA-Classic 53.33 %, and SALT 40.00 % ($p=0.000$) (Figure 2).

4. Consideration

According to the result of this study, there was no statistically significant difference in success rate of intubation for each airway device conducted indoor. It is likely due to the fact that students, subject of this research, have been accustomed to ET tube and LMA-Classic through repeti-

tive practice prior to the experiment. In case of SALT, it is attributable to the fact that there is no big difference in usage compared to previous airway device and students get accustomed to it during given performance time. Also, it may be due to the fact that subject put more energy on SALT practice which they are not accustomed to rather than practice of already accustomed airway devices. However, in regards to success rate of airway device intubation conducted within ambulance during the transfer, the success rate of all three airway devices plunged so as to present statistically significant difference. While only 8 failed ET tube conducted indoor, 25 have failed it within ambulance during the transfer. It may be attributable to the trait of ET tube which requires more advanced technique of examining the vocal cord with naked eyes and conducting the intubation through maintenance of the posture where the chin is lifted with only one hand. Since there was no big difference for LMA-Classic and SALT based on the location, the selection of airway devices such as LMA-Classic and SALT shall be considered when airway device intubation shall be conducted in unstable environment. In regards to performance time of three airway devices, it presented statistically significant difference in both indoor and ambulance scenario different from preceding studies. According to study by Kim et al which compared pre-hospital stage airway maintenance

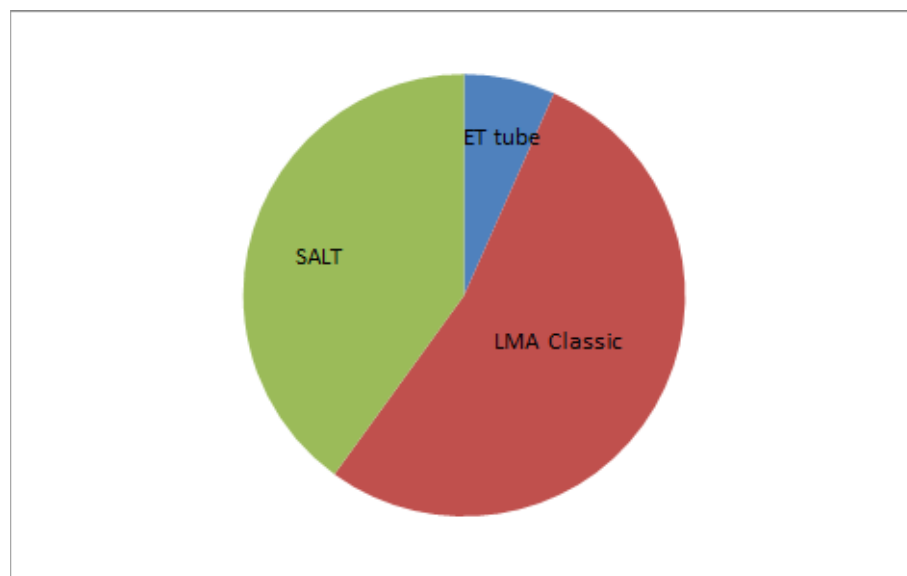


Figure 2. Preference of each airway device.

tools such as LMA-Classic, Cobra PLA, and King LT with the use of mannequin, it was reported that there is no statistically significant difference in primary success rate and performance⁵. A study by Turan et al which compared the use of LMA-Classic, Cobra PLA, and laryngeal tube with patients who received short-term surgery of within 1 hour under general anesthesia as its subject also reported that there is no big difference in intubation time for each tool⁶. However, it is considered that less time was spent since the subject of study by Kim et al consisted of 28 grade 1 emergency medical technicians, 1 grade 2 emergency medical technician, and 1 nurse all working on site different from the subject of this study which consists of students with less experience. In regards to the study by Turan et al, it was because of application to actual patients under anesthesia rather than mannequin. It was revealed through research that the most time is required for the use of SALT among three types of airway devices for both indoor and ambulance scenario. It may be due to additional time spent to insert a support before intubation into vocal cord. However, it can be considered as an effective device to conduct relatively consistent airway device intubation in unstable environment as time difference between indoor and ambulance scenario was the least among three airway devices. Although there was no statistically significant difference between total performance time of three airway devices for indoor scenario, there was statistically significant difference when it was conducted within ambulance. Such result seemed attributable to ET tube with low success rate within ambulance and it reconfirmed the fact that intubation within moving ambulance requires more advanced technology and focus compared to intubation in stable environment. The adequate location for endotracheal intubation shall provide sufficient ventilation to entire lung on both sides with placement of end of tube at the top of trachea and maintain sufficient depth and adequate cuff status so that there is no detubation followed by the movement of patients⁷. However, the depth of tube for intubation was inconsistent particularly when it was assessed within ambulance compared to the result of airway device intubation conducted indoor. This may be due to the fact that subject only focused on success rate and performance time of airway device intubation which are the assessment standard. Although endotracheal intubation is examined with observation and auscultation for its adequacy after the treatment, the examination is difficult with auscultation

when it is accompanied with lung contusion, hemothorax, pneumothorax, aspiration pneumonia, etc. Also, same respiration on both sides at auscultation does not signify that it is placed at adequate location based on trachea. In 1976, Conrardy et al conducted a study on location change in endotracheal intubation tube based on flexure and extension of collum since distance between intubation tube and trachea changed based on movement and location of collum due to such reason^{7,8}. In 1987, Owen et al examined its adequacy by fixing tube to 23cm for male and 21cm for female and taking x-ray with the consideration on the movement of collum before x-ray based on height of normal tube⁹. In 1995, Okgyeong Choi et al proposed to fix tube at 22cm for male and 20cm for female considering the change in distance based on the movement of collum asserting that fixation method based on the length of tube which applied the figure of overseas countries is not suitable for Korean with relatively small body¹⁰. Since inadequate location of tube brings about various complications including detubation, laryngospasm, respiration pneumonia, and others, it is crucial to focus on adequate location of intubation tube when conducting education on airway devices to students. The fact that side effects or difference that occurs from application to actual patients cannot accurately be grasped since it was simulation study using mannequin can be considered as the limitation of this study. Also, since it was study which conducts comparative experiment only on airway devices such as ET tube, LMA-Classic, and SALT, it is proposed that comparative study with various airway devices including LMA Proseal, Cobra PLA, King LT, and others shall be conducted. However, the significance of this study can be found in an aspect that its subjects include representative airway device ET tube and LMA-Classic which are widely used not only in hospital but also on-site and SALT which is an airway device yet to be introduced in Korea. Therefore, it is necessary to conduct a study which applies and assesses SALT airway device on site in the future.

5. Conclusion

As a result of conducting pre-hospital stage airway devices ET tube, LMA-Classic, and SALT indoor with the use of mannequin and with students majoring in emergency rescue as its subject, there was no statistically significant difference in success rate of intubation and total perfor-

mance time excluding intubation performance time. However, when it was conducted within moving ambulance, statistically significant difference was presented in all of intubation success rate, performance time, and total performance time. Also, in regards to preference survey on each airway devices conducted with research subjects, it was revealed that subjects preferred LMA-Classic the most.

6. References

1. Work range of paramedic [Internet]. [Cited 2015 Nov 15]. Available from: <http://www.law.go.kr/lsBylInfoR.do?bylSeq=4661830&lsiSeq=132927>.
2. Eun SJ, Kim H, Jung KY, Cho KH, Kim Y. Prospective multi-center evaluation of prehospital care by 119 rescue services. *Journal of Korean Society of Emergency Medicine*. 2007 Jun; 18(1):367–89.
3. Rescue and first aid activity results [Internet]. [Cited 2014 Jun 08]. Available from: <http://www.nema.go.kr/>.
4. Stiell S, Ma M, Prekker P. Denver metro airway study group. A prospective multi-center evaluation of prehospital airway management performance in a large metropolitan region. *Prehospital Emergency Care*. 2009 Jul; 13(3):304–10.
5. Kim YL, Lee HY, Kim GW, Jo HS, Jung JH. Comparative study of prehospital airway devices tested using a manikin model: a comparison of the Laryngeal Mask Airway Classic (LMA Classic), Cobra Perilaryngeal Airway (Cobra PLA) and the King Laryngeal Tube (King LT). *Journal of Korean Society of Emergency Medicine*. 2010 Dec; 21(6):776–82.
6. Turan A, Kaya G, Koyuncu O, Karamanlioglu B, Pamukcu Z. Comparison of the Laryngeal Mask (LMA) and Laryngeal Tube (LT) with the new Perilaryngeal Airway (CobraPLA) in short surgical procedures. *European Journal of Anaesthesiology*. 2006 Mar; 23(3):234–8.
7. Orf J, Thomas SH, Ahmed W, Wiebe L, Chamberlin P, Wedel S. Appropriateness of endotracheal tube size and insertion in children undergoing air medical transport. *Pediatric Emergency Care*. 2000 Oct; 16(5):321–7.
8. Conrardy PA, Goodman LR, Lainge F, Singer MM. Alternation of endotracheal tube position: Flexion and extension of the neck. *Critical Care Medicine*. 1976 Jan; 4(1):8–12.
9. Owen RL, Cheney FW. Endobronchial intubation; a preventable complication. *Anesthesiology*. 1987 Aug; 67:255–7.
10. Choi OK, Lee SH, Chung SP, Jung KY. Proper depth of placement of endotracheal intubation in Korean. *Journal of Korean Society of Emergency Medicine*. 1995 Jun; 6(1):220–6.