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Comparison of intubation times using a manikin with an immobilized cervical spine: Macintosh laryngoscope vs. GlideScope vs. fiberoptic bronchoscope

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Objective Airway management in patients with suspected cervical spine injury is classified as a "difficult airway." The best device for managing difficult airways is not known. Therefore, we conducted an intubation study simulating patients with cervical spine injury using three devices: a conventional Macintosh laryngoscope, a video laryngoscope (GlideScope), and a fiberoptic bronchoscope (MAF-TM). Success rates, intubation time, and complication rates were compared.

Methods Nine physician experts in airway management participated in this study. Cervical immobilization was used to simulate a difficult airway. Each participant performed intubation using airway devices in a randomly chosen order. We measured the time to vocal cord visualization, time to endotracheal tube insertion, and total tracheal intubation time. Success rates and dental injury rates were compared between devices.

Results Total tracheal intubation time using the Macintosh laryngoscope, GlideScope, and fiberoptic bronchoscope was 13.3 (range, 11.1 to 20.1), 14.9 (range, 12.7 to 22.3), and 19.4 seconds (range, 14.1 to 32.5), respectively. Total tracheal intubation time differed significantly among the devices (P=0.009). Success rates for the Macintosh laryngoscope, GlideScope, and fiberoptic bronchoscope were 98%, 96%, and 100%, respectively, and dental injury rates were 5%, 19%, and 0%, respectively.

Conclusion The fiberoptic bronchoscope required longer intubation times than the other devices. However, this device had the best success rate with the least incidence of dental injury.

Keywords Airway management; Bronchoscope; Head trauma

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CEEM

Capsule Summary

What is already known

Airway management in patients with suspected cervical spine injury is classified as a "difficult airway." In this case, it has not been established which device should be the gold standard.

What is new in the current study

The fiberoptic bronchoscope required longer intubation times than the other devices. However, this device had the best success rate with the least incidence of dental injury.

INTRODUCTION

The head-tilt chin-lift maneuver for airway management is not performed clinically in patients with suspected cervical spine injury. These cases are classified as "difficult airway" cases because of their limited cervical mobility.[1] However, no gold standard intubation device has been reported for use in patients with limited cervical motion due to neck immobilization. Additionally, while the Macintosh and video laryngoscopes have often been chosen for study, studies involving fiberoptic bronchoscopes are rare. Therefore, we conducted a study on airway management in simulated trauma victims who received cervical immobilization using an airway training manikin. We compared the success rates, time required for intubation, and rates of complication during intubation using three airway management devices: a Macintosh laryngoscope, a video laryngoscope, and a fiberoptic bronchoscope.

This study aimed to find the fastest and most successful intubation device for use in cervical immobilized patients with suspected cervical spine injury.

METHODS

Study participants

Volunteers experienced in intubation with video and fiberoptic bronchoscopes were recruited from two general hospitals and a university hospital. Nine volunteers who consented participated in this study. Study participants were airway experts with experience in airway management using all devices for more than 1 year. All of the participants were intensive care specialists in the fields of pulmonology, emergency medicine, and anesthesiology (Table 1).

Simulation devices

The following three airway devices were used: Macintosh laryngoscope (Welch Allyn, Skaneateles Falls, NY, USA), video laryngoscope (GlideScope; Verathon Medical Inc., Bothell, WA, USA), and fiberoptic bronchoscope (MAF-TM; Olympus Medical Systems, Tokyo, Japan).

The Airway Trainer (Laerdal, Stavanger, Norway) was used as the simulation manikin. A one-piece extraction cervical collar AMBU (Ambu Inc., Linthicum, MD, USA) was applied to the manikin for cervical immobilization. An additional band plaster was applied from the manikin's forehead to the table to limit neck motion.

A lubricated endotracheal (ET) tube with a 7.5-mm internal diameter was used. A conventional oral airway was applied in all trials except the bronchoscopic trial, in which the Ovassapian fiber optic intubating airway was used (Kendall Argyle, New York, NY, USA). A semi-rigid stylet was used for Macintosh laryngoscopic intubation. The GlideRite rigid stylet was used for GlideScope intubation.

All of the simulation studies were recorded using a digital camcorder (HMX-H405BD, Samsung, Seoul, Korea), and data were analyzed using a video player.

Table 1. Summary of participant characteristics

Participant	Specialty	Subspecialty	Experience in specialty (yr)	Experience in airway team (yr)
1	Emergency medicine	Critical care medicine	5	2
2	Emergency medicine	Critical care medicine	3	1
3	Emergency medicine	Critical care medicine	3	1
4	Pulmonology	Critical care medicine	3	1
5	Pulmonology	Critical care medicine	3	1
6	Pulmonology	Critical care medicine	4	2
7	Anesthesiology	Critical care medicine	9	-
8	Anesthesiology	-	6	-
9	Anesthesiology	-	3	-

Simulation methods

Participants were allowed to practice freely with the three devices on a manikin for 1 week prior to the experiment. Each participant performed intubations for six cycles in this study. Each cycle was performed using airway devices in a randomly chosen order.

The participants performed pre-oxygenation of the manikin using bag mask ventilation and prepared for intubation. Participants then performed intubation using the selected device. After insertion, participants connected the bag valve to the ET tube, and the manikin was ventilated to confirm successful ET intubation.

Time measurement began from the selection of the device. The time from device selection to vocal cord identification was defined as the time to vocal cord visualization. This time was indicated by participant's vocal expression upon visualizing the vocal cords. The time from vocal cord identification to ET tube insertion and ventilation of the artificial lungs was defined as the time to ET tube insertion. The sum of the two measured times was defined as the total tracheal intubation time. As in previous similar studies, failed intubation was defined as an intubation time > 150 seconds or esophageal intubation.

The manikin was designed to generate a "click" sound when significant pressure was applied on the upper incisors. We recorded the presence of dental injury and complications when a "click" sound was generated during the study. Participants subsequently conducted the procedure despite the "click" sound.

Statistical analysis

All data are described as median values with a range. Categorical variables were analyzed using the chi-square test. A Kruskal-Wallis test was performed to analyze differences in continuous variables between the three groups. Thereafter, post-hoc tests for two groups were performed using the Mann-Whitney test. Statistical significance was considered present when the P-value was less than 0.05 in a two-sided test. All statistical analyses were performed using PASW Statistics ver. 18.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

Total tracheal intubation time

Total tracheal intubation times using the Macintosh laryngoscope, GlideScope, and fiberoptic bronchoscope were 13.3 (range, 11.1 to 20.1), 14.9 (range, 12.7 to 22.3), and 19.4 seconds (range, 14.1 to 32.5), respectively. Total tracheal intubation times differed significantly among the devices (P = 0.009). Analyses of the Macintosh laryngoscope and GlideScope did not show any differences in the total tracheal intubation time. Statistically significant differences in total tracheal intubation times were found with the Macintosh laryngoscope compared to fiberoptic bronchoscope and the GlideScope compared to fiberoptic bronchoscope (P = 0.008 and P = 0.024, respectively) (Fig. 1).

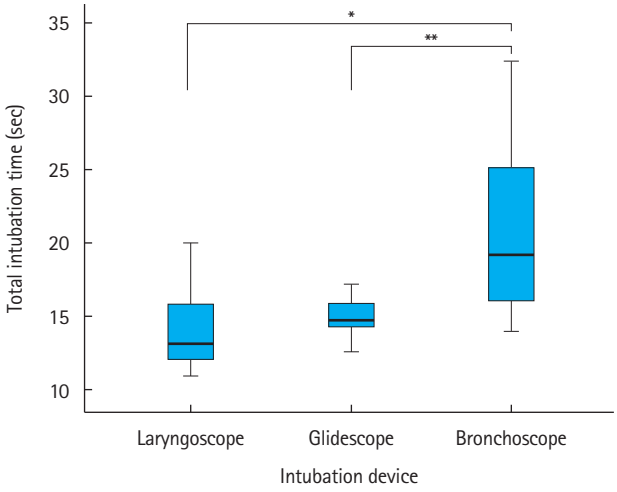

Fig. 1. Total intubation time using each intubation device. *P = 0.008. **P = 0.024.

Analysis of time to vocal cord visualization and endotracheal tube insertion

Times to vocal cord visualization using the Macintosh laryngoscope, GlideScope, and bronchoscope were 5.8 (range, 4.0 to 11.6), 6.4 (range, 5.0 to 10.9), and 8.4 seconds (range, 4.9 to 16.9), respectively. No statistically significant difference was found in the time to vocal cord visualization between the three devices (P = 0.428). Times to ET tube insertion using the Macintosh laryngoscope, GlideScope, and fiberoptic bronchoscope were 7.5 (range, 5.5 to 8.7), 8.4 (range, 6.8 to 11.9), and 10.5 seconds (range, 7.5 to 24.1), respectively. The times to ET tube insertion using each device were significantly different (P = 0.005; Macintosh laryngoscope vs. GlideScope, GlideScope vs. fiberoptic bronchoscope, and Macintosh laryngoscope vs. fiberoptic bronchoscope with P = 0.047, P = 0.064, and P = 0.003, respectively) (Fig. 2).

Success and complication rates

Fifty-four intubations were conducted using each device. Intubation attempts using the Macintosh laryngoscope failed once, and attempts using the GlideScope failed twice. All attempts using the fiberoptic bronchoscope were successful within 150 seconds. Dental injury (i.e., "click" sound) occurred three times with the Macintosh laryngoscope and 10 times with the GlideScope but did not occur with the fiberoptic bronchoscope (Table 2).

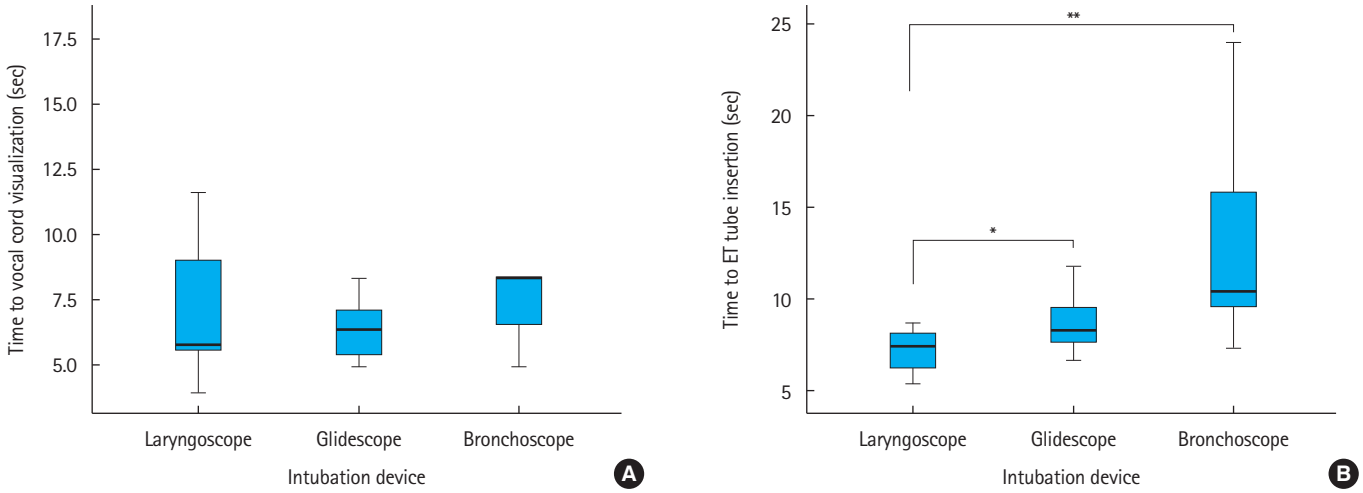

Fig. 2. Visualization of the vocal cords using each device (A). Endotracheal (ET) tube insertion time using each device (B). *P = 0.047. **P = 0.003.

Table 2. Intubation failure and dental injury rates

Device	Intubation failure	Dental injury
Laryngoscope	1 (2)	3 (5)
GlideScope	2 (4)	10 (19)
Bronchoscope	0 (0)	0 (0)

Values are presented as number (%).

DISCUSSION

The incidence rate of cervical spinal injury in blunt trauma is estimated to range from approximately 0.9% to 3%. The incidence of cervical spinal injury increases in cases with a Glasgow Coma Scale ≤ 8 or a focal neurological deficit.[2]

The primary survey in the advanced trauma life support guidelines in severely injured trauma victims recommends the subsequent evaluation and treatment of the airway, breathing, circulation, disability, and exposure.[3] These guidelines suggest that airway management be conducted using a cervical immobilization collar or manual in-line immobilization technique to protect the cervical spine.[4,5] ET intubation is the standard of care to secure the airway of severely ill or injured patients. However, the application of a semi-rigid cervical collar reduced mouth opening, inter-incisor distance, and degree of neck extension from 10°–15° to 4°–5°.[6,7]

The difficult airway algorithm recommends alternative approaches to failed intubation such as awake intubation, blind intubation, fiberoptic intubation, laryngeal mask airway, retrograde intubation, and invasive intubation.[8] Recently, alternative equipment was developed for difficult airway management. ET intubation using the GlideScope is widely researched, and this device is used clinically, especially in the management of a difficult airway.[9,10] One advantage of ET intubation using the GlideScope includes improved glottic views.[11]

However, an important limitation of this device is the hindrance in the passage of the ET tube through the vocal cords. This hindrance is caused by the arytenoid cartilages, the anterior commissure of the glottis, the interarytenoid soft tissues, or the cricoid cartilage.[12] Therefore, a rigid stylet is recommended to guide the ET tube through the vocal cords.[13,14]

Fiberoptic bronchoscopic intubation is a good alternative ET intubation technique in patients with an expected or known difficult airway or as a replacement device after a failed intubation.[8] Particularly, anesthesiologists have used the fiberoptic bronchoscope in patients with anticipated cervical spine disease. The advantages of this device are the minimal cervical movement required to achieve ET intubation in awake patients and the capability to perform post-intubation neurological assessments. Dunham et al.[15] reported that the success rate of ET intubation using the fiberoptic bronchoscope in trauma patients was 83.3%. However, there are relatively few studies on the use of the fiberoptic bronchoscope in emergency airway management after trauma.[15]

Our results are similar to those found in previous studies regarding cervical immobilization. Wetsch et al.[16] compared the GlideScope Ranger, McGrath Series 5, Storz C-Mac, Pentax Airway Scope, Airtraq, and Macintosh laryngoscope under similar conditions and found that video laryngoscopes did not provide effective ET intubation in patients with an immobilized cervical spine compared to a Macintosh laryngoscope.

However, only a few full-scale studies compared a fiberoptic bronchoscope with new alternative devices using a trauma patient simulator. Koyama et al.[17] compared the Airway Scope with a fiberoptic bronchoscope and gum elastic bougie in a manikin with a difficult laryngoscopic view. The Airway Scope may enable fast-

er and easier ET intubation than a gum elastic bougie or fiberoptic bronchoscope. A recent study including obese patients demonstrated no evident differences in the intubation time using the GlideScope and fiberoptic bronchoscope.[18]

Specialists with more than 1 year of experience using each device performed the simulations in this study. A fiberoptic bronchoscope was applied by all volunteers in clinical practice. The anesthesiologists were trained to use the fiberoptic bronchoscope since their residency. The pulmonologists were members of the in-hospital airway team and had intubated more than 100 times/yr with the devices used in this study including more than 50 times/yr using fiberoptic bronchoscopy. The emergency physicians also had intubated with the fiberoptic bronchoscope over 50 times/yr, as they were members of the in-hospital airway team. All volunteers were allowed unlimited practice using the devices before the study.

The results demonstrated that the total intubation time using a Macintosh laryngoscope was significantly shorter than when using the fiberoptic bronchoscope. The intubation time using the GlideScope was also shorter than when using the fiberoptic bronchoscope. There was no significant difference between the Macintosh laryngoscope and GlideScope in total intubation time. The intubation times for these devices were 4.5 seconds and 6.1 seconds, respectively. We analyzed the intubation procedure data to understand the reason for these differences. There was no difference in times to vocal cord visualization among the three devices. However, the time to ET tube insertion showed differences among the three devices. These differences were likely due to the different procedural methods required during the intubation process compared to the procedures for familiar devices.

In determining the superiority of an intubation device, one must consider the total intubation time and the success and dental injury rates. There was no dental injury or episodes of intubation failure when using the fiberoptic bronchoscope. The intubation failure and dental injury rates of the other devices were 2% to 4% and 5% to 19%, respectively. The fiberoptic bronchoscope has obvious advantages in reducing the failure rate and dental injuries.

This study has several limitations. First, the number of study participants was small, and participants' levels of experience with the specific devices varied. The study included specialists who had more than 1 year of experience with the devices and were currently practicing intubation procedures, but there were differences in familiarity with the equipment depending on the specialist's field of expertise. However, it was difficult to recruit specialists who were familiar with all three devices, because the devices used in this study are not included in the regular airway management curriculum. Therefore, the small potential pool of participants included in this study limited the variety of specialists and the number of experiments that could be performed. Another limitation is that the results of the three devices may not accurately reflect the results in actual human patients because human anatomical models were used. In contrast to an actual human tongue, the procedure of sliding the tongue aside when it is attached to the hard palate is not required when performing intubation on the manikin models. This difference makes it difficult to predict the extent and type of actual differences for each device. Each device has alternate methods for the management of oral secretion, bleeding, and injury that may occur during intubation in human patients. Therefore, it is difficult to assess these differences. Additionally, there was a tendency for the participants to be more aggressive in their intubation attempts and less concerned about the complications, possibly because they were performing intubation in anatomical models rather than their human counterparts. For example, if a tooth fracture occurred in actual human patients, it is highly unlikely that the participants would disregard this complication and continue with the procedure. The fact that this study used only manikin models for all of the procedures may have resulted in the higher incidence of dental injuries compared to other studies.

In conclusion, this study compared the intubation time, complications, and intubation success rate of three devices by simulating trauma patients with an immobilized cervical spine. The fiberoptic bronchoscope required a longer intubation time than the existing equipment, but it exhibited superiority in terms of dental injury and success rates. Follow-up comparative studies in actual human patients are needed.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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