Comparison of the GlideRite to the Conventional-malleable-stylet for Endotracheal Intubation by the Macintosh-Laryngoscope: A Simulation Study Using Manekins

Yong Tack Kong, M.D. 1, Hyun Jung Lee, M.D. 1, Ji Ung Na, M.D. 1, Dong Hyuk Shin, M.D. 1, Sang Kuk Han, M.D. 1, Jeong Hun Lee, M.D. 2, Pil Cho Choi, M.D. 1

Department of Emergency Medicine, Kangbuk Samsung Hospital, Sungkyunkwan University School of Medicine, Seoul1, Department of Emergency Medicine, College of Medicine, Dongguk University, Goyang2, Korea

Purpose: The purpose of this study is to compare the effectiveness of the GlideRite with the conventional-malleable-stylet (CMS) in endotracheal intubation (ETI) using the Macintosh-laryngoscope.

Methods: This study is a randomized crossover simulation study. Participants performed ETI using both the GlideRite and the CMS in the normal airway and in a tongue edema (simulated difficult airway resulting in lower percentage of glottis opening [POGO] model).

Results: In both the normal and the tongue edema models, all 36 participants performed ETI successfully using the two stylets on the first attempt. In the normal airway model, there was no difference in time required for ETI ($T_{ETI}$) or ease of handling between the two stylets. In the tongue edema model, the $T_{ETI}$ increased as POGO score decreased with the CMS (POGO score showing negative correlation with $T_{ETI}$ for the CMS, Spearman’s $\rho=-0.518$, $p=0.001$) but not for the GlideRite ($\rho=-0.208$, $p=0.224$). The $T_{ETI}$ was shorter with the GlideRite than the CMS, but without statistical significance (15.1 vs. 18.8 seconds, $p=0.385$). Ease of handling was superior with the GlideRite compared to the CMS ($p=0.006$).

Conclusion: Performance of the GlideRite and the CMS was not different in the normal airway model. However, in the simulated difficult airway model with a low POGO score, the GlideRite performed better than the CMS for direct laryngoscopic intubation.

Key Words: Instrumentation, Intubation intratracheal, Manekins

What is already known in the previous study
Molding of the conventional malleable stylet in a hockey stick shape by bending the distal 10 cm of the stylet-embedded endotracheal tube 30 degrees in a forward direction is generally recommended to enhance endotracheal intubation.

What is new in the current study
Use of the J-shaped rigid GlideRite stylet tailored for the GlideScope in conventional orotracheal intubation resulted in faster and easier endotracheal intubation in the tongue edema model with a low percentage for the glottic opening score.

Introduction

Endotracheal intubation (ETI) is a treatment for patients in ventilation failure, and ETI delay or failure may adversely affect patient outcome. Therefore, it is recommended that physicians with enough clinical experience and skill perform ETI. However, in emergency situations, skilled physicians may not always be available. Moreover, skilled physicians can still experience difficulties performing ETI if the patient has a difficult airway with a low percentage of glottic opening (POGO) score. Various types of video-laryngoscopy have been introduced and have been shown in some studies to be superior to traditional Macintosh-laryngoscopy in obtaining a view of the glottis. However, traditional Macintosh-laryngoscopy remains the most common procedure in ETI. For successful ETI with the Macintosh-laryngoscope, it is essential to obtain the glottic view and to accurately insert the endotracheal tube all the way from the mouth to the obtained view of the glottic opening.

Conventional malleable stylet (CMS) is commonly used in the emergency department to aid insertion of the
endotracheal tube during ETI. The shape of the CMS can be modified according to the shape of the blade of the laryngoscope or the preference of the user. In general, a 15 to 30 degree bend of the distal 10 cm of the stylet towards the front enables the user to easily operate the stylet embedded endotracheal tube. Bending of the distal part of the stylet is especially helpful if the glottis is located on the upper part of the visual field or if only the bottom part of the glottis is visible (low POGO score). The bent distal part of the stylet can help the endotracheal tube tip be located near the glottic opening and therefore enables passage of the endotracheal tube through the vocal cords

GlideRite (Verathon Medical Inc., Bothell, WA, USA) is a reusable, rigid J-shaped stylet developed to enhance ETI using a Gli-deScope (Verathon Medical Inc.). Distal end of the GlideRite is 70 degree bent forward and has a thumb tab to enhance stylet removal with one hand. Sakles and kalin reported that the GlideRite has higher first attempt success rate and lower incidence of oxygen desaturation than the CMS. Jones et al. and Turkstra et al. reported that there are no difference in time to intubation, first attempt success rate and ease of intubation between the GlideRite and the CMS. However, there are no studies that investigated the usefulness of the GlideRite in direct laryngoscopic intubation, to the best of our knowledge.

In real clinical practice, authors found that the J-shaped rigid stylet used during Glidescopic ETI was easier to control and handle than the CMS. Therefore, we hypothesized that the GlideRite may also be more useful than the CMS not only in GlideScope assisted indirect video laryngoscopic intubation but also in direct laryngoscopic intubation using the Macintosh-laryngoscope. We performed this study to compare the performance of CMS and GlideRite in direct laryngoscopic intubation in normal and difficult airway scenarios.

Materials and Methods

1. Study design and subjects

This study was a randomized simulation study performed in a teaching hospital. The flow diagram of this study is shown in Fig. 1. Participants were recruited from a group of medical doctors applying for internship at our hospital. All had recently graduated from medical school. Those who volunteered to participate after a brief explanation of the study were included.

Study participants were recruited from novice medical doctors who have little or no experience in direct laryngoscopic intubation to avoid difference in learning curve between the participants. Level of inexperience was arbitrarily set as “not more than 10 times of successful direct laryngoscopic intubation”, of which number the success rate is predicted to be less than 40%. Those who had successfully performed ETI with a Macintosh-laryngoscope more than 10 times before recruitment were excluded from the research. The study protocol was reviewed and approved by the institutional review board of Kangbuk Samsung Hospital (KBC 14024).

2. Study protocol

An ALS Simulator (Laerdal, Stavanger, Norway) was used for this simulation study. Normal airway and difficult airway scenario (simulated by tongue edema) were used to compare performance of two different stylets. Normal airway scenario required no manipulation on the manikin. Difficult airway scenario was created by inflating the tongue with a pressure of 180 mmHg, which usually results in a Cormack-Lehane grade III glottis view with the manikin in a sniffing position.

Standard education about ETI with the Macintosh-laryngoscope was provided for 30 minutes. Before actual performance in real study, participants were required to practice until they consecutively succeed more than 3 times with each of two stylets (GlideRite and CMS). In order to reproduce the in-hospital situation, the height of the table was set to waist high. For every ETI, the manikin’s head and neck were maintained in a sniffing position by placing an 8 cm tall pillow at the occipital region of the manikin.

A number 4 Macintosh blade was used during the intubations. Two kinds of stylets, CMS (Muraco Medical, Tokyo, Japan) and GlideRite, were prepared. The shape of the CMS was linear until the cuff and the distal part was bent to 35 degrees in the frontal direction (Fig. 2). Water soluble lubricant was applied to stylet and endotracheal tube to ease the process of stylet removal and endotracheal tube passage.
The order of the airway model and the type of stylet was randomized by choosing cards before the study. Participants performed four ETIs in total, one for each airway and stylet combination. Between each ETI, participants were instructed to take at least a one-minute break to rest, and they were allowed to take several extra minutes of rest until they felt fully recovered.

3. Study outcome

The act of inserting and removing the blade of the laryngoscope from the mouth was considered as one ETI attempt. For each ETI, three attempts were allowed, and 3 or more failures were considered as failure of ETI. The time required for intubation (T_{ETI}) was measured from the time the endotracheal tube was handed to the participants by the assistant to the time they removed the stylet. The participants prepped the stylet with lubricant and placed it inside the endotracheal tube right before the ETI attempt while one assistant held the prepared endotracheal tube. The participant positioned the blade of the laryngoscope at vallecula and said “I see it” at the point where the glottis was most clearly visible. Then the assistant handed the endotracheal tube to the participant.

**Fig. 1.** Flow diagram.
CMS: conventional malleable stylet
Every procedure was video recorded in close-up. The success rate, the number of attempts, and $T_{ETI}$ were measured to compare the effectiveness of the different stylets. After each ETI attempt, the operator reported the POGO score and the easiness of handling by using a 5 point Likert scale (1, very difficult; 2, difficult; 3, neutral; 4, easy; 5, very easy).

For estimation of the required sample size, a pilot study was conducted to calculate the time (mean and standard deviation) spent in ETI, as published information in this area was not available. Five emergency medical doctors conducted ETI by using the CMS and the GlideRite with the tongue edema model. An average of $17 \pm 8$ seconds was spent processing the ETI with the CMS, and an average of $12 \pm 6$ seconds was spent processing the ETI with the GlideRite. Based on this pilot study with $a=0.05$ and $b=0.2$ level, a sample size of 32 was reckoned.

4. Statistical analysis

Mann-Whitney U-tests were used to assess whether different types of airway models affect $T_{ETI}$ and ease of ETI. Correlation analysis was used to assess the relationship between the POGO score and $T_{ETI}$. For continuous variables with a normal distribution, the mean and standard deviation were reported. For continuous variables that did not follow a normal distribution, the median and interquartile range were reported. STATA ver. 13.0 (StataCorp LP., College Station, TX, USA) was used for all analyses. $p$-values less than 0.05 were considered statistically significant.

## Results

A total of 36 medical doctors participated in this study. The mean age of the participants was $29.5 \pm 3.8$ years. The number of male participants was 23 (64%). Twenty-two participants (61%) had previous clinical experience in ETI. The median number of ETI was 1 (interquartile range [IQR], 0-4).

1. Normal airway model

In the normal airway model, all 36 participants successfully performed ETI on the first attempt with both stylets. The median POGO score was 80% (IQR, 70-90). The POGO score did not differ significantly between the two stylets ($p=0.511$). Neither $T_{ETI}$ ($p=0.954$) nor the handling score ($p=0.186$) differed significantly between the two stylets (Table 1). In ETI with the CMS, the POGO score and $T_{ETI}$ were not significantly correlated (Spearman’s rho=0.199, $p=0.244$). Likewise, in ETI with
the GlideRite, the POGO score and T\textsubscript{TEI} were not significantly correlated (rho=-0.137, \(p=0.426\)) (Fig. 3).

Table 1. Comparison of the outcomes of the conventional-malleable-stylet and the GlideRite in the normal airway model

<table>
<thead>
<tr>
<th></th>
<th>Conventional malleable stylet (N=36)</th>
<th>GlideRite (N=36)</th>
<th>(p)-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>POGO score</td>
<td>80 (70-90)</td>
<td>80 (60-90)</td>
<td>0.506</td>
</tr>
<tr>
<td>Time required for endotracheal intubation, sec</td>
<td>8.2 (6.6-9.5)</td>
<td>7.8 (5.2-10.6)</td>
<td>0.665</td>
</tr>
<tr>
<td>Ease of handling*</td>
<td>4 (3-4)</td>
<td>4 (3-5)</td>
<td>0.186</td>
</tr>
</tbody>
</table>

Data are presented as median (interquartile range).
POGO: percentage of glottic opening
* 5 point Likert scale (1, very difficult; 2, difficult; 3, neutral; 4, easy; 5, very easy).

Table 2. Comparison of the outcomes of the conventional-malleable-stylet and the GlideRite in the tongue edema (simulated difficult airway) model

<table>
<thead>
<tr>
<th></th>
<th>Conventional-malleable-stylet (N=36)</th>
<th>GlideRite (N=36)</th>
<th>(p)-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>POGO score</td>
<td>20 (15-40)</td>
<td>30 (10-40)</td>
<td>0.846</td>
</tr>
<tr>
<td>Time required for endotracheal intubation, sec</td>
<td>12.1 (9.8-17.6)</td>
<td>15.3 (7.7-18.8)</td>
<td>0.800</td>
</tr>
<tr>
<td>Ease of handling*</td>
<td>3 (2-3)</td>
<td>3 (2-4)</td>
<td>0.006</td>
</tr>
</tbody>
</table>

Data are presented as median (interquartile range).
POGO: percentage of glottic opening
* 5 point Likert scale (1, very difficult; 2, difficult; 3, neutral; 4, easy; 5, very easy).

Fig. 3. Scatter plots of the time required for intubation and the percentage of glottic opening (POGO) score for each styles and each airway models. (A) With the conventional malleable stylet in the normal airway model, rho=0.199 (\(p=0.244\)), (B) with the GlideRite in the normal airway model, rho=-0.137 (\(p=0.426\)), (C) with the conventional malleable stylet in the tongue edema model, rho=-0.518 (\(p=0.001\)), and (D) with the GlideRite in the tongue edema model, rho=-0.208 (\(p=0.224\)).
model, all 36 participants successfully performed ETI on the first attempt with both stylets. The median POGO score was 30% (IQR, 10-40). The POGO score did not differ significantly between the two stylets ($p=0.846$). The TETI was $18.8 \pm 24.1$ sec in CMS and $15.1 \pm 9.3$ sec in the GlideRite. Although ETI with the CMS took longer than with the GlideRite, this difference was not statistically significant ($p=0.385$). However, participants felt that the GlideRite was easier to handle than the CMS. The handling score was significantly higher with the GlideRite than with the CMS (3 [IQR, 2-4] with the GlideRite versus 3 [IQR, 2-3] with the CMS, $p=0.006$) (Table 2). In ETI with the CMS, the POGO score and $T_{ETI}$ were significantly negatively correlated ($\rho=-0.518$, $p=0.001$). When the operator performed ETI with the CMS, $T_{ETI}$ increased as the POGO score decreased. In contrast, in ETI with the GlideRite, the POGO score and $T_{ETI}$ were not significantly correlated ($\rho=-0.208$, $p=0.224$) (Fig. 3). When the operator performed ETI with the GlideRite, $T_{ETI}$ did not increase as the POGO score decreased.

### Discussion

The stylet is one of the oldest pieces of ancillary equipment that aids successful ETI. The stylet eases the operation of endotracheal tube during the ETI process. In cases with a difficult airway, a stylet can improve the success rate of ETI and decrease the time required for ETI9,15-18). Anesthesiologists do not recommend routine use of a stylet for elective ETI if the patient has normal airway anatomy, is fully sedated, and has relaxed muscles. However, use of a stylet is widely accepted in the emergency department where a greater number of patients with difficult ETI situations are encountered1,17,19-22). Various types of stylets are currently in use23). However, CMS is one of the most commonly used stylets for ETI by direct laryngoscope. The recommended shape of the CMS during ETI is a hockey-stick shape that is straight until the cuff with a curved distal end6,8,9). The GlideRite is a J-shaped rigid stylet that is suitable for ETI with the GlideScope. The distal end of this stylet is more curved (closer to 70 degrees) than other commonly used stylets. This shape improves control of the stylet because the distal end of the endotracheal tube is clearly visible from the video monitor’s glottis field of view.

Usefulness of the GlideRite in GlideScope assisted intubation is supported by previous studies results which reported that performance of the GlideRite is better or similar to that of the CMS10-12). However, there are no evidences about the usefulness of GlideRite in direct laryngoscopic intubation using the Macintosh-laryngoscope. This study is the first to compare the effectiveness of the GlideRite with the CMS during ETI with the Macintosh-laryngoscope.

In real clinical practices, authors experienced that the rigid J shape of the GlideRite makes it easy to place the endotracheal tube tip at the glottis opening and the thumb tab enhance stylet removal and endotracheal tube handling. In normal airway scenario, the performance of the GlideRite and the CMS was not different. However, in difficult airway scenario, POGO score had significant negative correlation with time to intubation in intubations using the CMS, but not with the GlideRite. In other words, if operators encounter difficult intubation cases with low POGO score, it is more likely that one can perform intubation better with the GlideRite than with the CMS.

Greenland et al.24) divided airway passage into oro-pharyngeal curve and pharyngo-glottio-tracheal curve, and the tangent at which two curves meet at the inflection point is affected by the head and neck position. If we incorporate the angle at the distal stylet tip into the angle formed by the visual line and the tangent at the inflection point, it is inferable that as the angle gets more vertical, the more vertically angled stylet should be necessary. In normal airway scenario, it is possible to flatten the oro-pharyngeal curve and the tangent at the inflection point with the Mac blade, sharply angled stylet may have no merit. However, in tongue edema model with low POGO score, as the tangent at the inflection point gets more vertical, the angle of the stylet tip should be more vertical. In difficult airway situations with low POGO score, more sharply angled stylet may be necessary than the conventional 35° angle recommended in malleable stylet6). However, if the angle of stylet tip gets too sharp, it may hinder the endotracheal tube advance after passing the vocal cords14). In a cadaver study, Levitan et al.14) reported that when using a direct laryngoscope, changing the curve of the distal end of the CMS to more than 45
degrees in the frontal direction hindered the ETI. The failure rate for ETI was 53.9% when CMS was curved 60 degrees in the frontal direction.

Considering that the GlideRite is curved 70 degrees in the frontal direction, there is a huge difference between the results of our study and Levitan’s research. This difference in ETI success rate could be explained by the different shapes of the two stylets. The 60-degree curved CMS used in their study was acutely angled at the distal end, but the curve of the J-shaped GlideRite begins more proximally with more gradual angulation. No participants complained about difficulties in advancing the endotracheal tube after passing the vocal cords, in this study. If the typical CMS could be modified more proximally to give it a gradual J shaped curve, the significant negative correlation between the POGO score and the TETI might not have occurred. However, a J-shaped CMS was not assessed in the current study.

All participants were inexperienced novice medical doctors considering that 14 had no actual clinical experience in endotracheal intubation and other 22 had only negligible experience with median attempt number of 1. Nevertheless, all participants successfully performed ETI in the normal airway and the tongue edema models. This unusually high success rate can be explained by several factors. First, all participants recently graduated from medical school and passed the objective structured clinical examination, which includes ETI with a manikin. Second, we gave all participants 30 minutes of standard instruction about ETI, as well as time to practice until they felt confident just before the study, which may have raised the success rate. Third, participants were enrolled in the study only after they successfully performed three consecutive ETIs. Finally, they performed ETI on a manikin, not a real patient, and the manikins had no intra-oral contaminant or difficulty in mouth opening.

This study has several limitations. First, this was a simulation study that used manikins, not real patients. The tongue edema model use to simulate difficult airway in this study cannot represent all other difficult airway situations in real clinical practice. Thus, clinical studies on the use of the GlideRite in ETI with Macintosh-laryngoscopy are needed. Second, potential airway injury relevant to each stylet during ETI was not evaluated in this study. Third, we only used CMS with 35° anterior bending, so other angles, such as 15° or 45°, were not considered.

Conclusion

When the CMS was used during ETI in the tongue edema model, lower POGO score were associated with longer TETI. However, when the GlideRite was used, the POGO score was not related to TETI. The GlideRite required a shorter TETI and was easier to handle than the CMS in the tongue edema model with a low POGO score. Therefore, the GlideRite may be considered as a first choice stylet in ETI by the Macintosh-laryngoscope, especially when difficult airway with low POGO score is anticipated or encountered.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

REFERENCES

7. Levitan RM, Heitz JW, Sweeney M, Cooper RM. The complexities of tracheal intubation with direct laryn-