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Comparison of the GlideRite to the conventional malleable stylet for endotracheal intubation by the Macintosh laryngoscope: a simulation study using manikins

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Objective To compare the effectiveness of the GlideRite stylet with the conventional malleable stylet (CMS) in endotracheal intubation (ETI) by the Macintosh laryngoscope.

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

Results In both the normal and tongue edema models, all 36 participants successfully performed ETI with the two stylets on the first attempt. In the normal airway model, there was no difference in time required for ETI (T_{ETI}) or in ease of handling between the two stylets. In the tongue edema model, the T_{ETI} using the CMS increased as the POGO score decreased (POGO score was negatively correlated with T_{ETI} for the CMS, Spearman's rho=-0.518, P=0.001); this difference was not seen with the GlideRite (rho=-0.208, P=0.224). The T_{ETI} was shorter with the GlideRite than with the CMS, however, this difference was not statistically significant (15.1 vs. 18.8 seconds, P=0.385). Ease of handling was superior with the GlideRite compared with the CMS (P=0.006).

Conclusion Performance of the GlideRite and the CMS were 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.

Keywords Intubation, intratracheal; Instrumentation; Manikins

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Capsule Summary

What is already known

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. The J-shaped rigid GlideRite stylet which is bent forward 70 degrees is tailored for GlideScopic intubation and is known to have some advantages over the conventional malleable stylet during indirect intubation using GlideScope.

What is new in the current study

The GlideRite required a shorter time for endotracheal intubation and was easier to handle than the conventional malleable stylet in the tongue edema model with a low percentage of 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.[1] Therefore, it is recommended that physicians with sufficient clinical experience and skill perform ETI.[2,3] However, in emergency situations, experienced 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.[4] 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.[5] 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.[6,7]

A 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 frontal direction 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 to be located near the glottic opening, and therefore, enables passage of the endotracheal tube through the vocal cords.[6,8,9]

GlideRite (Verathon Medical Inc., Bothell, WA, USA) is a reusable, rigid, J-shaped stylet developed to enhance ETI using a GlideScope (Verathon Medical Inc.). The distal end of the GlideRite is bent forward 70 degrees and has a thumb tab to enhance stylet removal with one hand.[7] Sakles and Kalin[10] reported that the GlideRite has a higher first-attempt success rate and lower incidence of oxygen desaturation than does the CMS. Jones et al.[11] and Turkstra et al.[12] reported that there are no differences in time-to-intubation, first-attempt success rate, and ease of intubation between the GlideRite and the CMS. However, to the best our knowledge, there are no studies that have investigated the usefulness of the GlideRite in direct laryngoscopic intubation.

In clinical practice, we found that the GlideRite used during ETI with the GlideScope was easier to control and handle than was 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.

METHODS

Study design and subjects

This 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. After a brief explanation of the study, those who volunteered to participate were included.

In order to avoid a difference in learning curve among participants, all study participants were novice physicians who had little or no experience in direct laryngoscopic intubation. Level of inexperience was arbitrarily set as "not more than 10 instances of successful direct laryngoscopic intubation"; the success rate of 10 successful intubations is predicted to be less than 40%.[13] Those

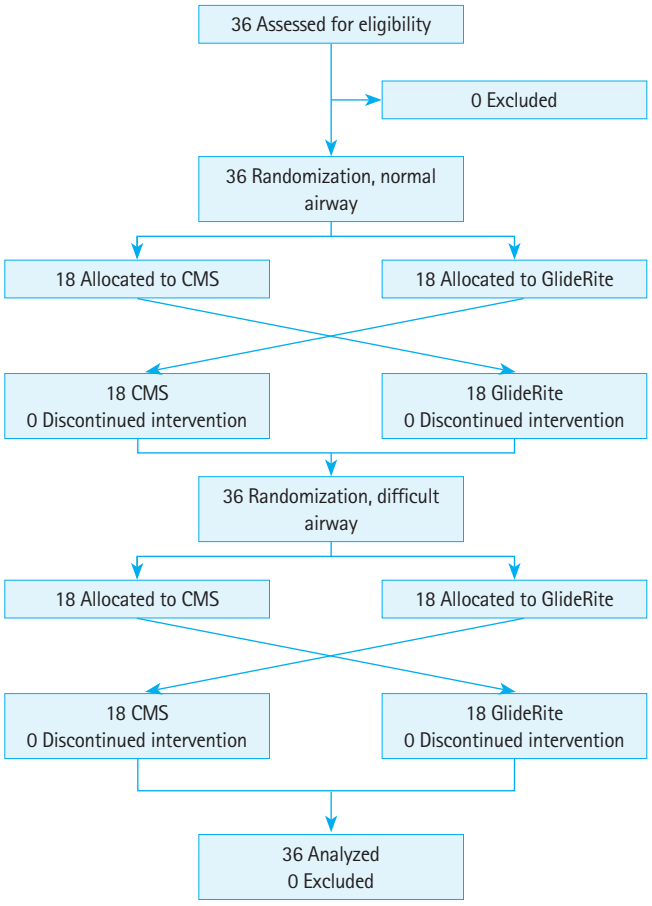

Fig. 1. Flow diagram of randomization and simulation process. CMS, conventional malleable stylet.

who had successfully performed ETI with a Macintosh laryngoscope more than 10 times before recruitment were excluded from the study. The study protocol was reviewed and approved by the institutional review board of Kangbuk Samsung Hospital (KBC 14024).

Study protocol

Standard education regarding ETI with the Macintosh laryngoscope was provided to participants for 30 minutes. Before performance in the actual study, participants were required to practice until they consecutively succeeded at ETI more than 3 times with each of the stylets (GlideRite and CMS).

An ALS simulator (Laerdal, Stavanger, Norway) was used. Normal and difficult airway scenarios (simulated by tongue edema) were used to compare the performance of the two different stylets. The normal airway scenario required no manipulation of the manikin. The difficult airway scenario was simulated by inflating the manikin's tongue to a pressure of 180 mmHg, which usually resulted in a Cormack-Lehane grade III glottis view with the manikin in a sniffing position.

In order to simulate 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 under the manikin's occipital region.

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).[6,9,14] Water-soluble lubricant was applied to the 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 the stylet were 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.

The act of inserting and removing the blade of the laryngoscope from the mouth was defined as one ETI attempt. For each ETI, three attempts were allowed, and three or more failures were considered an ETI failure. The time required for ETI (T_{ETI}) was measured from the time the endotracheal tube was handed to the participant by the assistant to the time the participant removed the stylet from the endotracheal tube. The participant prepped the stylet with lubricant and placed it inside the endotracheal tube just prior to the ETI attempt. While the participant positioned the laryngoscope blade, an assistant held the prepared endotracheal tube. The participant positioned the blade of the laryngoscope at the 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. Every procedure was video recorded in a close-up mode. The success rate, number of attempts, and T_{ETI} were measured to compare the effectiveness of the two stylets. After each ETI attempt, the participant recorded the POGO score and the ease of handling by using a 5 point Likert scale (1, very difficult; 2, difficult; 3, neutral; 4, easy; 5, very easy).

Statistical analysis

For estimation of the required sample size, a pilot study was conducted to calculate the time (mean and standard deviation) spent performing ETI, as published information in this area was not available. Five emergency physicians conducted ETI using both the CMS and the GlideRite with the tongue edema model. An average of 17 ± 8 seconds was spent performing the ETI with the CMS, and an average of 12 ± 6 seconds was spent performing 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 calculated.

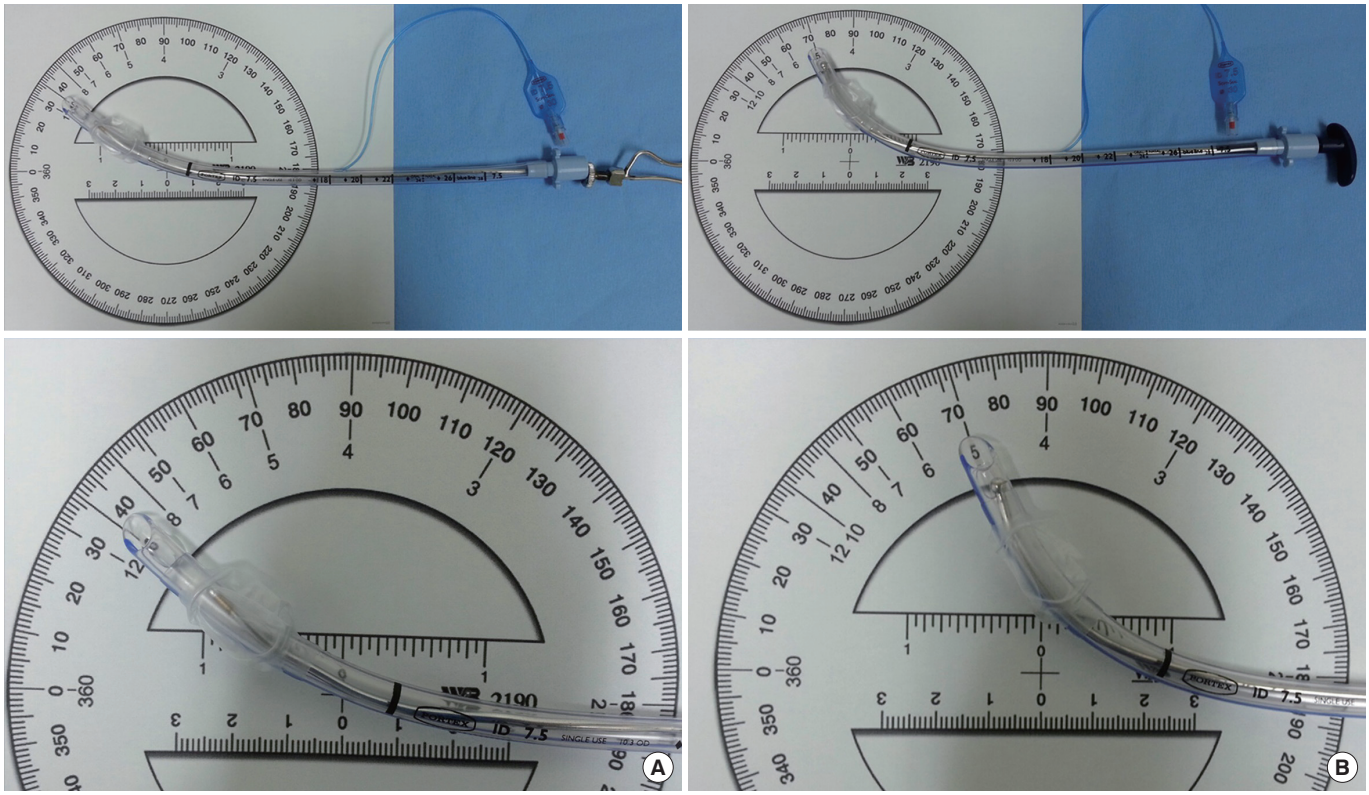

Fig. 2. The conventional malleable stylet (A) and the GlideRite stylet (B) with the endotracheal tube. The degree of bend is 35 (A) and 70 (B).

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., College Station, TX, USA) was used for all analyses. P-values less than 0.05 were considered statistically significant.

RESULTS

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

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 to 90). The POGO score did not differ significantly between the two stylets (P=0.511). Neither T_{ETI} (P=0.954) nor handling score (P=0.186) differed significantly between the two stylets (Table 1). During ETI with the CMS, the POGO score and T_{ETI} were not significantly correlated (Spearman's rho=0.199, P=0.244). Likewise, during ETI with the GlideRite, the POGO score and T_{ETI} 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 stylet in the normal airway model

	Conventional malleable stylet (n=36)	GlideRite stylet (n=36)	P-value
POGO score	80 (70–90)	80 (60–90)	0.506
Time required for endotracheal intubation (sec)	8.2 (6.6–9.5)	7.8 (5.2–10.6)	0.665
Ease of handling[a]	4 (3–4)	4 (3–5)	0.186

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

Tongue edema (simulated difficult airway) model

In the tongue edema (simulated difficult airway) model, all 36 participants successfully performed ETI on the first attempt with both stylets. The median POGO score was 30% (IQR, 10 to 40).

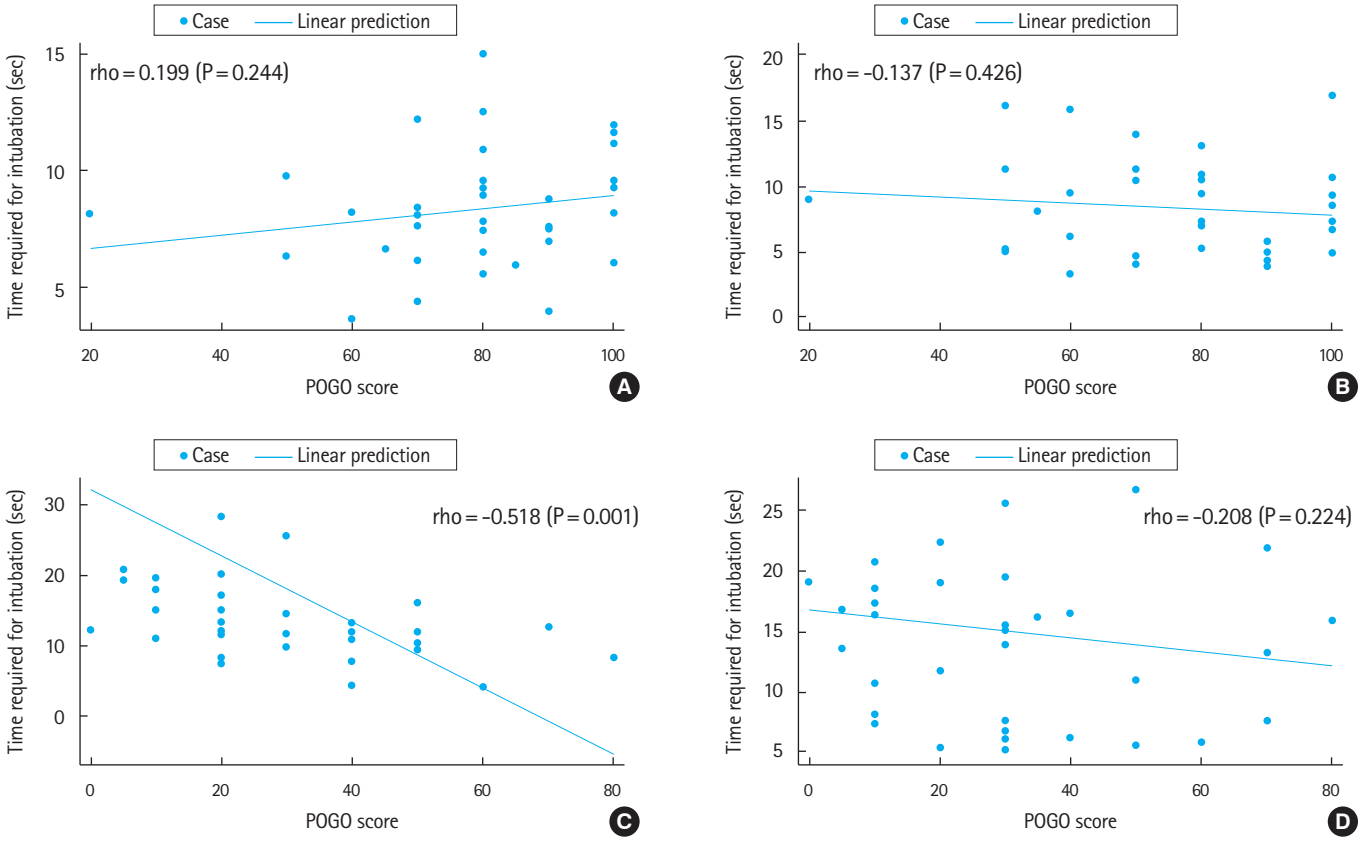

Fig. 3. Scatter plots of the time required for intubation and the percentage of glottic opening (POGO) score for each stylets and each airway models. (A) With the conventional malleable stylet in the normal airway model, (B) with the GlideRite in the normal airway model, (C) with the conventional malleable stylet in the tongue edema model, and (D) with the GideRite in the tongue edema model.

The POGO score did not differ significantly between the two stylets (P = 0.846). The T_{ETI} was 18.8 ± 24.1 seconds using the CMS and 15.1 ± 9.3 seconds using the GlideRite. Although ETI with the CMS took longer than with the GlideRite, this difference was not statistically significant (P = 0.385). However, participants reported that the GlideRite was easier to handle than was the CMS. The handling score was significantly higher with the GlideRite than with the CMS (3 [IQR, 2 to 4] vs. 3 [IQR, 2 to 3], P = 0.006) (Table 2). During ETI with the CMS, the POGO score and T_{ETI} were significantly negatively correlated (rho = -0.518, P = 0.001). When the participant 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 participant performed ETI with the GlideRite, T_{ETI} did not increase as the POGO score decreased.

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

	Conventional malleable stylet (n = 36)	GlideRite stylet (n = 36)	P-value
POGO score	20 (15–40)	30 (10–40)	0.846
Time required for endotracheal intubation (sec)	12.1 (9.8–17.6)	15.3 (7.7–18.8)	0.800
Ease of handling[a]	3 (2–3)	3 (2–4)	0.006

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

DISCUSSION

The stylet is one of the oldest ancillary instruments used to aid successful ETI. The stylet eases the insertion of the 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 ETI.[9,15-18] 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 encountered.[1,17,19-22] Various types of stylets are currently in use.[23] 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, it is straight until the cuff with a curved distal end.[6,8,9] The GlideRite is a J-shaped rigid stylet that is suitable for ETI with the GlideScope. The distal end of this stylet has a greater curve (closer to 70 degrees) than other commonly used stylets. This shape improves the control of the stylet because the distal end of the endotracheal tube is clearly visible from the video monitor's glottis field of view.

The 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 CMS.[10-12] However, there is no evidence regarding 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 clinical practice, we have experienced that the rigid J shape of the GlideRite makes it easy to place the endotracheal tube tip at the glottis opening, and that the thumb tab enhances stylet removal and endotracheal tube handling. In the normal airway scenario of our simulation, the performance of the GlideRite and the CMS were not different. However, in the difficult airway scenario, the POGO score had a significant negative correlation with time-to-intubation in intubations using the CMS, but not in intubations using the GlideRite. In other words, if operators encounter difficult intubation cases with a low POGO score, it is more likely that one can perform intubation more efficiently with the GlideRite rather than with the CMS.

Greenland et al.[24] divided airway passage into an oro-pharyngeal curve and a pharyngo-glotto-tracheal curve; the tangent at which the 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 inferred that as the angle becomes more vertical, then the more vertically angled stylet should be preferable.

In the normal airway scenario, it is possible to flatten the oropharyngeal curve and the tangent at the inflection point with the Macintosh blade, such that a sharply angled stylet may have no merit. However, in the tongue edema model with a low POGO score, as the tangent at the inflection point becomes more vertical, the angle of the stylet tip should be more vertical. In difficult airway situations with a low POGO score, a more sharply angled stylet may be necessary over the conventional 35-degree angle recommended with the malleable stylet.[6] However, if the angle of the stylet tip becomes too sharp, it may hinder advancement of the endotracheal tube after passage through the vocal cords.[14] In a cadaver study, Levitan 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.[14] The failure rate for ETI was 53.9% when the 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. This difference might result in this study in participants not complaining of difficulties in advancing the endotracheal tube after passing the vocal cords. 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 T_{ETI} might not have occurred. However, a J-shaped CMS was not assessed in the current study.

All participants were inexperienced novice physicians, considering that 14 had no actual clinical experience in ETI and the other 22 had only negligible experience with a median attempt number of 1. Nevertheless, all participants successfully performed ETI in the normal airway and 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 on ETI, as well as time to practice before the study until they felt confident performing the procedure. Third, participants were enrolled in the study only after they successfully performed three consecutive ETIs. Finally, they performed ETI on a manikin, not on 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 used to simulate difficult airway in this study cannot represent all other difficult airway situations in clinical practice. Thus, clinical studies on the use of the GlideRite in ETI with the Macintosh laryngoscopy are needed. Second, potential airway injury relevant to each stylet during ETI was not evaluated. Third, we only used CMS with a 35-degree anterior bend; therefore, other angles, such as 15 or 45 degrees, were not evaluated.

In summary, when the CMS was used during ETI in the tongue edema model, a lower POGO score was associated with a longer T_{ETI}. However, when the GlideRite was used, the POGO score was not related to T_{ETI}. The GlideRite required a shorter T_{ETI} 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 a difficult airway with a low POGO score is anticipated or encountered.

CONFLICT OF INTEREST

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

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