This article has been accepted for publication and has undergone full peer review but has not been through the copyediting, typesetting, pagination, and proofreading processes, which may lead to differences between this version and the version of record.

Please cite this article as https://doi.org/10.4097/kja.22716
The usefulness of C-curved stylet for intubation with the C-MAC® Miller videolaryngoscope in neonates and infants: A prospective randomized controlled trial

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Running title: C-curved stylet for infant intubation

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Previous presentation in conferences: None

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

Funding statement: None

IRB number: 2011-196-1178 (The institutional review board of Seoul National University Hospital; Chairperson, Byung-joon Park; Date of approval, 13 January 2021)
Clinical trial registration number: NCT04745936

Acknowledgements

Ji-Hyun Lee has been an editor for the Korean Journal of Anesthesiology since 2021. However, she was not involved in the review process of this article, including peer reviewer selection, evaluation, or decision-making. There were no other potential conflicts of interest relevant to this article.
The usefulness of C-curved stylet for intubation with the C-MAC® Miller videolaryngoscope in neonates and infants: A prospective randomized controlled trial

Running title: C-curved stylet for infant intubation
Abstract

**Background:** Optimizing endotracheal tube shape is important for successful videolaryngoscope-aided intubation. This prospective randomized controlled study aimed to evaluate the efficacy of using a C-curved stylet on the tube-handling time in infants and neonates using the C-MAC® videolaryngoscope Miller blade.

**Methods:** A total of 110 infants (age <1 year) were randomly assigned to either the hockey stick-curved stylet group (group H, n = 53) or the C-curved stylet group (group C, n = 57). The primary outcome was tube-handling time after glottis visualization, and the secondary outcomes were the total intubation time, incidence of successful intubation, initial tube tip location at the laryngeal inlet, and numerical rating scale for ease of intubation.

**Results:** Tube insertion time and total intubation duration (both in seconds) were significantly shorter in group C than in group H (13.3 ± 8.9 vs. 25.1 ± 27.0, \( p = 0.002 \); 19.9 ± 9.4 vs. 32.8 ± 27.1, \( p = 0.001 \), respectively). Group C displayed a higher rate of intubation success within 30 s than group H (87.7% vs. 69.8%, \( p = 0.013 \)). The initial tube tip was located at the center in 34 children in group C (59.6%) and 12 children in group H (26.1%, \( p < .001 \)). Laryngoscope operators rated intubation as easier when provided with a C-curved stylet.

**Conclusions:** Modification of the endotracheal tube shape into a C-curve may reduce tube handling time compared to the conventional hockey stick-shaped tube during intubation using a C-MAC® video laryngoscope Miller blade in neonates and infants.

**Keywords:** infants; intubation; neonates; videolaryngoscope; airway management; endotracheal tube shape
Introduction

Airway management of infants and neonates is challenging because of the higher difficulty of intubation and high susceptibility to hypoxemia [1]. Owing to their small size, relatively difficult airway intubation, high oxygen consumption per unit of body weight, and small functional residual capacity, these patients are associated with an increased risk of airway management with several complications [2]. Anesthesiologists encounter hypoxemia much faster in neonates and infants, even during a brief period of apnea during intubation [2, 3]. Moreover, multiple consecutive intubation attempts may contribute to increased morbidity [1]. Therefore, the identification of an optimal regimen for successful intubation in the minimum time for small children is of paramount importance [4].

According to a recent large-scale multicenter randomized controlled trial, the use of a videolaryngoscope improved the first-attempt success rate and reduced complications, such as hypoxemia, airway trauma, laryngospasm, and oesophageal intubation, in infants weighing 6.5 kg or less [5]. The C-MAC® (Karl Storz, Tuttlingen, Germany) is a widely used videolaryngoscope that has standard Miller blade sizes #0 and #1, which are suitable for use in neonates and infants [5-7]. Compared to the McGrath MAC size #1 blade and direct laryngoscopy, the C-MAC® Miller blade provides superior-quality glottis view in neonates and infants [7].

Despite the improved laryngeal view, endotracheal tube (ETT) delivery to the laryngeal inlet and the passage of the ETT into the glottis remain challenging in infants and neonates as the ETT tip gets lodged against the anterior tracheal wall because of the anatomical features of an angled vocal cord, relatively small oropharynx, and large tongue [1, 8]. Furthermore, even a small motion generated by the operator makes the ETT move significantly in the glottis view of the device. Therefore, optimizing the ETT shape to facilitate operator handling constitutes an important factor for successful tracheal intubation in a short time [4, 8]. In adult patients, a 90°-angled hockey-stick-shaped stylet could
facilitate successful intubation using a videolaryngoscope. McElwain et al. demonstrated that a hockey-stick stylet configuration significantly reduces intubation time compared to other stylet shapes, including a C-curved shape, when using a C-MAC videolaryngoscope with a standard MAC blade [9]. Nevertheless, few studies have investigated the ideal ETT stylet shape for neonates and infants [8].

Considering the limited size of the oropharyngeal cavity in neonates and infants, we assumed that a C-curve-shaped stylet that resembles the natural ETT curve could facilitate ETT handling than a hockey-stick-shaped stylet. Therefore, this prospective randomized controlled study was conducted to compare the time to target and deliver the tip of the ETT to the glottis by using the C-curve-shaped and conventional hockey stick-shaped tubes using a C-MAC® video laryngoscope in neonates and infants.
Materials and Methods

Study Population

This prospective randomized controlled study was approved by the institutional research ethics committee, registered at http://clinicaltrial.gov before patient enrollment, and performed at our institution between March 2021 and April 2022.

Children younger than 12 months who were scheduled for elective surgery requiring endotracheal intubation under general anesthesia at a single tertiary referral center were enrolled. Patients with upper respiratory tract infection symptoms, abnormal airways, or severe uncompensated cardiopulmonary diseases, and those classified as American Society of Anesthesiologists (ASA) grade IV–V were excluded from this study. The study protocol was thoroughly explained to the parents, and written informed consent was obtained from the parents of all patients prior to the surgery. This study was performed in accordance with the tenets elucidated in the Declaration of Helsinki and its amendments.

Randomization and ETT Preparation

Patients were randomly assigned to either the hockey stick-curved stylet group (group H) or the C-curved stylet group (group C). For randomization, an online response system (http://www.randomizer.org) was used with a 1:1 allocation ratio. Sequentially numbered opaque sealed envelopes were prepared by a researcher who was not involved in this study to conceal group allocation. The operator identified the allocated group by opening the envelope immediately before induction.

All patients were intubated with a cuffed ETT, in accordance with the institutional standard of care. Tube size was determined as described by Salgo et al.[10]. The curvature of the ETT (Shiley, Hi-Countour Oral/Nasal Tracheal Tube, Covidien, Germany) was prepared according to its designated...
group by using Flexible Stylet (2 mm PORTEX® stylet; Smiths Medical International Ltd. Kent, UK). In the hockey stick-curved stylet group (group H), the configuration of the distal tube tip was angled to resemble a ‘hockey stick’ and its shaft remained straight as in the manufactured state (Fig 1a). In the C-curved stylet group (group C), the distal tube tip was angled in a large C-shape to maintain the original curvature of the tube (Fig 1b). We made ETT templates for both the hockey stick-curved and C-curved ETTs to maintain the consistency of the ETT angle throughout the study.

Anesthesia and Outcome Variables

Routine monitoring was initiated immediately after the patient was admitted to the operating room. After pre-oxygenation, the patient was intravenously administered atropine (0.2 mg/kg) and thiopental sodium (5–6 mg/kg). Rocuronium bromide (0.6–1.2 mg/kg) was used for neuromuscular blockade. Facial mask ventilation was performed with sevoflurane and 100% oxygen. After the disappearance of the single twitch response, the patients were intubated using a C-MAC® videolaryngoscope with a Miller blade size #0 or #1 and a predetermined ETT with a loaded stylet. While maintaining the patient’s head in the neutral position, the operator inserted the tube after securing the best glottic view through a C-MAC® videolaryngoscope. All intubation attempts were performed by anesthesiology residents with experience of at least 30 direct laryngoscopies in infants and neonates. To reduce errors in the recording measurement process, all procedures from insertion to withdrawal of the videolaryngoscope were video-recorded.

When the patient’s oxygen saturation decreased below 95%, the intubation procedure was suspended, and manual ventilation with 100% oxygen was initiated to restore oxygen saturation to 98–100% before any further intubation attempt. The number of intubation attempts was counted as ETT insertion into the patient’s oropharynx and its withdrawal from the oral cavity. When the operators failed to advance the ETT through the glottis during the first attempt, they were allowed to either
change the stylet curvature or maintain the original stylet curvature. However, when the stylet curvature was changed or the number of attempts exceeded two, the cases were defined as failed intubations.

A single investigator, who was blinded to the group allocation, reviewed the videos and collected the data for analysis. We divided the total intubation time into three epochs: (1) the time to glottis visualization after C-MAC® videolaryngoscope insertion (T0), (2) the time to approach the ETT tip to the glottis after glottis visualization (T1), and (3) the time to advance the ETT cuff fully through the glottis after inserting the ETT tip into the glottis (T2). The time required for each step was recorded. The primary outcome was tube handling time (T1 + T2). The secondary outcomes included the total intubation time (T0 + T1 + T2), the duration of T1 and T2, the initial location of the ETT tip on the monitor of the C-MAC® videolaryngoscope, the modified Cormack and Lehane grade, the incidence of successful intubation in the first attempt within 30 seconds, the number of intubation attempts, and the need for any optimization techniques such as external laryngeal manipulation, head extension, or stylet curvature change. The operators rated subjective intubation difficulty on a 10-point numerical rating scale (0 = extremely easy, 10 = extremely difficult) [11].

The initial ETT tip location at the laryngeal inlet and the locational changes of the tip after redirection were recorded regardless of its position in the center. The space around the laryngeal inlet on the monitor of the videolaryngoscope was divided and named, as shown in Fig 1c. The ‘center’ was defined as the space along the upper border of the epiglottis to the lower border of cuneiform cartilage and corniculate cartilage. The upper part of the epiglottis was defined as the ‘anterior’ region and the lower part of the center and anterior space were divided into three divisions. The ‘posterior’ region was defined as the division just below the center, and ‘Left’ and ‘Right’ as the division located on either side of the posterior division. All positional changes in the ETT tip were recorded before intubation. Information on patient characteristics, such as age, sex, height and weight, and type of surgery were collected from the
patients’ electronic medical records.

Statistical analysis

The sample size was calculated based on a previous study comparing two stylet curvatures during intubation using a videolaryngoscope in infants [12]. According to the study, the tube insertion time was significantly higher in the hockey stick-curved stylet group than in the spiral-shaped stylet group (18.2 ± 5.3 s vs. 15.4 ± 4.7 s; \( p = 0.012 \)). Taking these values as a reference, 52 patients per group were required to detect a difference of 2.8 s in the tube insertion time between the two groups using a two-sided Student’s \( t \)-test with an \( \alpha \) error of 0.05 a power of 80%. Considering a dropout rate of 10%, the participant numbers were calculated as 114 patients (57 patients per group).

Normality was assessed using the Shapiro–Wilk W-test. Data are expressed as the mean and standard deviation, or median and interquartile range for parametric variables, and as frequencies/percentages for nonparametric variables. Categorical variables were compared using Pearson’s chi-square test and Fischer’s exact test when more than 20% of the cells had expected frequencies of <5. Continuous data were compared using Student’s \( t \)-test or Mann–Whitney rank-sum test. Statistical analysis were performed using the SPSS (ver. 23.0; IBM Inc). Statistical significance was set at \( p<0.05 \).
Results

A total of 114 participants were enrolled in the present study, and 4 were excluded after enrollment due to changes in their surgical plans that did not necessitate endotracheal intubation. Therefore, the data of 53 children in group H and 57 children in group C were analyzed (Fig 2). Baseline patient characteristics are shown in Table 1. Patient characteristics, including age, height, weight, sex, and type of surgery, were comparable between the two groups.

Table 2 shows the data on the intubation process between the two groups. The tube handling time after glottis visualization (T1 + T2) was significantly shorter in group C than in group H (13.3 ± 8.9 s vs. 25.1 ± 27.0 s, respectively; mean difference, −11.8 s; 95% confidence interval [CI], −19.3 to −4.3; p = 0.002). Although the time to glottis visualization (T0) was comparable in both groups, the total intubation time (T0 + T1 + T2) in group C (19.9 ± 9.4 s) was significantly shorter than that of group H (32.8 ± 27.1 s; mean difference, −13.0 s; 95% CI, −20.5 to −5.4; p = .001). However, there was no difference in the distribution of operators’ residency years between the two groups. As the modified Cormack and Lehane grade was ≤ 2a in all patients, no additional maneuvers to improve the glottis views, such as the use of cricoid pressure or laryngeal manipulation, were performed.

Tracheal intubation was successful in all patients in group C after a single attempt without additional attempts. However, more than two intubation attempts were required for six patients (11.3%) in group H, and five of them altered the ETT curvature to a C curve for successful tracheal intubation. In group C, 88.5% of patients was intubated within 30 s, whereas 69.8% of group H was intubated within 30 s (mean difference, 18.7%; 95% CI, 2.4%–34.5%; p=0.029).

The initial tube tip location on the videolaryngoscope monitor was at the center in 34 children in group C (59.6%) and 12 children in group H (26.1%; mean difference, 33.5%; 95% CI, 13.9–50.4%; p < 0.001). If the initial tip location was placed in the center, the tube handling time (T1+T2) did not
significantly differ between the two groups (mean ± SD; 7.8 ± 9.0 s vs. 18.08 ± 34.9 s; mean difference, −10.26 s; 95% CI, −32.5 to 12.0; \( p = 0.334 \); Fig 3). In addition, both the time taken to approach the ETT tip to the glottis (T1) and the time required for tube advancement (T2) showed no statistical intergroup difference (\( p = 0.542 \) and \( p = 0.334 \), respectively). However, in patients in whom the tube tip was not initially centered at the laryngeal inlet, the T1 + T2 was significantly shorter in group C (4.0 ± 2.6 s vs 13.6 ± 24.2 s; mean difference −9.61 s; 95% CI, −17.314 to −1.905; \( p = 0.016 \)). Furthermore, the patients in group H required more time to approach (T1) and advance the ETT into the vocal cords (T2) (\( p = 0.009 \) and \( p = 0.016 \), respectively).

Operators rated intubation as easier when a C-curved ETT was used (Table 2). Hypoxemia (SpO2 <90%) occurred in two patients in group H, whereas none of the patients in group C experienced desaturation.
Discussion

In this prospective randomized controlled study, the use of a C-curved ETT significantly decreased the time to target and deliver the tip of the ETT to the glottis compared with the hockey stick-shaped ETT for intubation with the C-MAC® Miller videolaryngoscope in infants and neonates. In addition, the C-shaped stylet facilitated the placement of the ETT in the center, thereby shortening the tracheal intubation time.

Considering the small-sized airways, small functional residual capacity, increased oxygen consumption, and technical issues, airway management in neonates and infants is challenging [1, 13]. Furthermore, several anatomical features of the pediatric airway such as the large tongue relative to the mandible and mouth size, long floppy, omega-shaped epiglottis, edentulous, cephalad larynx, and anterior vocal cords make ETT manipulation in infants and neonates more difficult [13, 14]. Therefore, it is essential to devise a method to quickly and accurately perform endotracheal intubation in infants and neonates on the first attempt.

The C-MAC® videolaryngoscope using a Miller blade is useful in providing an improved glottic view in pediatric patients, according to previous studies [6, 15, 16]. In the present study, no patients were classified as Cormack-Lehane grade III or IV with the C-MAC® videolaryngoscope with Miller blade. Furthermore, the time to glottis visualization was significantly shortened in neonates undergoing intubation with the C-MAC videolaryngoscope (7.7 ± 0.1 sec.) compared to the Miller direct laryngoscope (11.3 ± 0.1 sec.) according to a recent pediatric study [17]. However, improved glottis visualization does not guarantee easy intubation. According to a recent large-scale multicenter study performed in infants, the success rate of first-attempt intubation using a C-MAC videolaryngoscope was high, but it did not guarantee a 100% success rate [5]. Therefore, videolaryngoscope devices usually require intubation adjuncts such as a stylet or a bougie to make the ETT shape more feasible for easy targeting and advancement through the glottis [8]. Furthermore,
the dynamic interplay of hand-eye coordination and visuospatial coordination is required for the successful manipulation of the ETT under the indirect vision of a videolaryngoscope [17]. To overcome the technical difficulty and guarantee the successful intubation, identifying an optimal shape of the ETT would be essential [1, 4, 12].

In this study, the use of the C curved ETT facilitated significant reduction in the tube handling time after the glottis visualization to 11.8 s and the time required for tube advancement by 3.5 s, compared to the hockey stick-shaped ETT. In addition, the total intubation time was 19 s in group C, which was 8 s less than the time reported in a previous study by Gupta et al., which compared the C-MAC Miller blade and the McGrath MAC blade [7]. Furthermore, during neonatal resuscitation, the safety window for intubation attempts is limited to 30 s [18, 19]. Saving 11 s during intubation trial may serve as a crucial factor in determining patient prognosis considering rapid desaturation during apnea in neonates and infants. We speculated that the acute angle of ETT in group H might prevent smooth advancement of ETT, facing multiple obstacles within narrow oropharyngeal cavity. Also, this required more additional manipulation while targeting the ETT to glottis, when compared to C-curved ETT (Fig 4).

Positioning the ETT tip in the center of the videolaryngoscope screen facilitates tracheal intubation and helps reduce intubation time, according to a previous study [12]. If the ETT tip points in an undesirable direction, additional handling for directing the ETT tip to the glottis is required. Owing to the structural differences in infants’ airways, the range of motion in the videolaryngoscope screen is relatively large, even with a small movement of the ETT, making its manipulation difficult. In this study, when the initial ETT tip position was placed at the center of the glottis, the median time for tube handling tracheal intubation was similar between the groups C (17 s) and H (18 s). However, these cases only occurred in approximately 26% of patients in group H, and this incidence was significantly lower than that in group C.
Additionally, the use of the C-curved stylet demonstrated a higher first-attempt success rate (100% vs. 90.6%) and a higher successful intubation rate within 30 s (88.5% vs. 69.8%) than the hockey stick-shaped stylet group performed by less-experienced clinicians. Five patients in the hockey stick group were successfully intubated after curvature change in the second tracheal intubation attempt. The reported success rate in the first attempt using the C-MAC video laryngoscope Miller blade in neonates and infants was 93-95.7% [5, 7] but there was no information regarding the shape of the stylet. Considering our first-attempt success rate, we concluded that C-curved ETT preparation helps improve intubation safety in infants and neonates.

Our study has several limitations. First, the operators were not blinded to the stylet allocation during the intubation period. However, an investigator who was blinded to the group allocation reviewed the records and analyzed the video data. As the length of the endotracheal tube visible through the screen until the tube tip reaches the glottis was too short to identify the shape of ETT, we assumed that the investigator was blinded for group allocation based on recorded videos. Additionally, operators were provided with a preformed tube immediately before intubation to reduce the bias. Second, we did not count the number of advancement maneuvers, such as withdrawing the ETT [5] or reverse loading of the ETT [4] to improve advancement through the vocal cords. However, we speculated that adding these maneuvers would be associated with more time for the successful completion of intubation, which was the outcome of this study. Third, we did not control the operators’ previous experience of videolaryngoscope, but we thought this might be reflected in operators’ grades and we found no difference in distribution of operators’ grades between two groups. In addition, the number of operators’ experience during study period was not limited. The total of 27 operators were participated in the study, and the median value of participation in each operators were 2 (interquartile ranges 2-6), assigned more than once to each group, less than 5 times in each group. Finally, infants suspected to have a difficult or abnormal airway were excluded from the study. Further research should focus on
the effect of different ETT shapes on successful intubation using various videolaryngoscopes in children with difficult airway.

In conclusion, the use of a C-curved stylet could reduce tube handling time and total intubation time compared to a hockey stick-shaped stylet using a C-MAC® videolaryngoscope in neonates and infants. It also improved the rate of successful intubation within 30 s and the positioning of the initial ETT tip to the center of the laryngeal inlet. Further research is needed to evaluate the effect of different stylet shapes on the intubation success rate using various videolaryngoscopes in cases of difficult airway management in children.
References


Table 1. Baseline Characteristics Demographics

<table>
<thead>
<tr>
<th></th>
<th>Group H (n=53)</th>
<th>Group C (n=57)</th>
<th>Mean or median difference [95%CI]</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (months)</td>
<td>2.18 ± 1.59</td>
<td>2.07 ± 1.56</td>
<td>-0.11 [-0.71 to 0.49]</td>
<td>0.713</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>55.77 ± 8.72</td>
<td>55.77 ± 8.72</td>
<td>-0.69 [-3.58 to 2.19]</td>
<td>0.635</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>4.76 ± 1.94</td>
<td>4.76 ± 1.53</td>
<td>0.00 [-0.66 to 0.65]</td>
<td>0.990</td>
</tr>
<tr>
<td>Gender (n, %)</td>
<td></td>
<td></td>
<td></td>
<td>0.418</td>
</tr>
<tr>
<td>Female</td>
<td>21 (39.6%)</td>
<td>28 (49.1%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>32 (60.4%)</td>
<td>29 (50.9%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of surgery (n, %)</td>
<td></td>
<td></td>
<td></td>
<td>0.741</td>
</tr>
<tr>
<td>General surgery</td>
<td>18 (34.0%)</td>
<td>23 (40.4%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urologic surgery</td>
<td>1 (1.9%)</td>
<td>2 (3.5%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiothoracic surgery</td>
<td>24 (45.3%)</td>
<td>23 (40.4%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neurosurgery</td>
<td>0</td>
<td>1 (1.8%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ophthalmic surgery</td>
<td>10 (18.9%)</td>
<td>8 (14.0%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data are presented as number (%) and mean ± standard deviation.
Table 2. Data of intubation process of the hockey stick curved stylet group and C curved stylet group

<table>
<thead>
<tr>
<th>Performer’s grade (n, %)</th>
<th>Group H (n = 53)</th>
<th>Group C (n = 57)</th>
<th>Mean or median difference, OR [95%CI]</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st year</td>
<td>8 (15.1%)</td>
<td>5 (8.8%)</td>
<td></td>
<td>0.292</td>
</tr>
<tr>
<td>2nd year</td>
<td>24 (45.3%)</td>
<td>33 (57.9%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3rd year</td>
<td>17 (32.1%)</td>
<td>18 (31.6%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4th year</td>
<td>4 (7.5%)</td>
<td>1 (1.8%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modified Cormack and Lehane grade</td>
<td></td>
<td></td>
<td></td>
<td>1.000</td>
</tr>
<tr>
<td>1</td>
<td>47 (88.7%)</td>
<td>50 (87.7%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2a</td>
<td>6 (11.3%)</td>
<td>7 (12.3%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time to best glottis view (T0) (sec)</td>
<td>7.8 ± 5.0</td>
<td>6.6 ± 3.9</td>
<td>-1.2 (-2.8 to 0.5)</td>
<td>0.172</td>
</tr>
<tr>
<td>Time to approach ETT tip to glottis after glottis visualization (T1) (sec)</td>
<td>10.4 ± 5.3</td>
<td>7.0 ± 3.5</td>
<td>-3.5 (-5.1 to -1.8)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Time to advance ETT cuff fully through the glottis (T2) (sec)</td>
<td>14.6 ± 26.7</td>
<td>6.3 ± 7.3</td>
<td>-8.3 (-15.9 to -0.8)</td>
<td>0.032</td>
</tr>
<tr>
<td>Tube handling time* (T1 + T2) (sec)</td>
<td>25.1 ± 27.0</td>
<td>13.3 ± 8.9</td>
<td>-11.8 (-19.3 to -4.3)</td>
<td>0.002</td>
</tr>
<tr>
<td>Total intubation time (T0+T1+T2) (sec)</td>
<td>32.8 ± 27.1</td>
<td>19.9 ± 9.4</td>
<td>-13.0 (-20.5 to -5.4)</td>
<td>0.001</td>
</tr>
<tr>
<td>Number of attempts (n, %)</td>
<td></td>
<td></td>
<td></td>
<td>0.026</td>
</tr>
<tr>
<td>1</td>
<td>47 (88.7%)</td>
<td>57 (100.0%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>5 (9.4%)</td>
<td>0 (0.0%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1 (1.9%)</td>
<td>0 (0.0%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Curve change (n, %)</td>
<td>5 (9.4%)</td>
<td>0 (0.0%)</td>
<td>9.4% (0.5 – 20.6%)</td>
<td>0.056</td>
</tr>
<tr>
<td>Overall success † (n, %)</td>
<td>47 (88.7%)</td>
<td>57 (100.0%)</td>
<td>11.3% (1.9 – 23%)</td>
<td>0.029</td>
</tr>
<tr>
<td>Successful intubation within 30 sec (n, %)</td>
<td>37 (69.8%)</td>
<td>50 (87.7%)</td>
<td>18.7% (2.4 – 34.5%)</td>
<td>0.029</td>
</tr>
<tr>
<td>Initial endotracheal tube tip location (n, %)</td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Center</td>
<td>12 (26.1%)</td>
<td>34 (59.6%)</td>
<td>33.5% (13.9 – 50.4%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Non-center</td>
<td>41 (73.9%)</td>
<td>23 (40.4%)</td>
<td>33.5% (13.9 – 50.4%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Anterior</td>
<td>1 (1.9%)</td>
<td>1 (1.8%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posterior</td>
<td>6 (11.3%)</td>
<td>4 (7.0%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>24 (45.3%)</td>
<td>8 (14.0%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>10 (18.9%)</td>
<td>10 (17.5%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NRS scale for ease of intubation</td>
<td>3 (2-5 [1-10])</td>
<td>2 (1-3 [1-6])</td>
<td></td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
Data are presented as number (%), mean ± standard deviation or median (interquartile ranges [ranges]).

*ETT insertion time after glottis visualization; †excluding intubation failure case, which was defined when stylet curve was changed or number of attempt was more than 2.

ETT, endotracheal tube; NRS, numeric rating scale
Figure legends

**Figure 1.** (A) Hockey stick-curved stylet (B) C-curved stylet (C) five sections of the space around the laryngeal inlet
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Figure 2. CONSORT flow diagram

Figure 3. Violin plots for time taken during procedure in both groups. Data were further classified as per initial tip location (center vs non-center).

A, tube handling time (T1 + T2); B, time to approaching endotracheal tube to glottis after glottis visualization (T1); C, tube insertion time since endotracheal tube approached glottis (T2)
The inner thick line within the plot represents the median time, and the other vertical lines of the violin plot represent the 10%, 25%, 75%, and 90% quartiles respectively.

Figure 4. Movement of endotracheal tube during endotracheal tube advancement from the oral cavity into the oropharynx.

(A) Hockey stick-curved stylet

(B) C-curved stylet