Effect of the curved blade size on the outcomes of tracheal intubation performed by incoming interns

A randomized controlled manikin study

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Abstract

Background: Novice clinicians who have little or no clinical experience in tracheal intubation occasionally need a long time to perform the procedure when using a large curved blade. They also have a lower tracheal intubation success rate, especially in emergency situations, such as cardiac arrest, than experienced practitioners. This study aimed to investigate whether the size of the curved laryngoscope blade affects the outcomes of tracheal intubation performed by incoming interns on a manikin model.

Methods: After completing a pre-study survey, the participants (n=221) were randomly assigned into the following 2 groups based on the curved blade size: size 3 (n=111) and size 4 (n=110) curved blade groups. This study was conducted during a 1-day boot camp for incoming interns. The participants performed tracheal intubations using Macintosh laryngoscopes with size 3 or 4 blades on a Laerdal Airway Trainer (Laerdal, Stavanger, Norway). Subsequently, the participants were asked to complete a post-study survey. The primary outcome was the time to successful intubation (TSI). Meanwhile, the secondary outcomes were the first-pass and overall success rates, self-reported proximal esophagus visualization, and esophageal intubation. All intubation attempts were recorded and assessed by a trained assistant. The data were analyzed using the Mann-Whitney U or Chi-square test.

Results: No significant differences in the baseline characteristics were observed between the 2 groups. The size 3 curved blade group had significantly shorter TSI than the size 4 curved blade group [25.0 (21.0–35.0) vs 36.5 (24.0–80.5) seconds, \( P < .001 \)]. In addition, the size 3 curved blade group had significantly higher first-pass and overall success rates than the size 4 group (\( P = .001 \) and \( P = .005 \), respectively). Meanwhile, the size 4 curved blade group showed higher proximal esophagus visualization and esophageal intubation incidence rates than the size 3 curved blade group.

Conclusion: The outcomes of direct orotracheal intubation performed by novice practitioners may be influenced by the blade’s size. Significant emphasis should be given on key anatomical landmarks and progressive visualization for tracheal intubation during airway management training for novice clinicians.

Abbreviation: TSI = time to successful intubation.

Keywords: anatomic landmarks, intratracheal intubation, laryngoscopes

1. Introduction

In emergency airway management, oxygenation and ventilation are the most important issues. When a patient is deteriorating in an emergency situation, earlier oxygenation can be achieved by alternative airway management techniques that can be performed safely by a novice clinician until expert help arrives. Nevertheless, if the maintenance of oxygenation is expected to be difficult, orotracheal intubation is usually performed. Orotracheal intubation is the main procedure performed for advanced airway management in emergency departments.\textsuperscript{[1–3]} Although the use of video laryngoscopy has recently increased, direct laryngoscopy remains to be more frequently used among adult patients than video laryngoscopy.\textsuperscript{[4,5]} The ability to perform orotracheal intubation using direct laryngoscopy is one of the most important airway management skills a clinician should have that is fundamental in the management of critically ill patients.

In the United States, emergency physicians manage almost all intubations in many emergency departments, whereas physician trainees initiate most intubations.\textsuperscript{[3,4]} Generally, physician trainees perform tracheal intubation under the supervision of
an attending emergency physician. However, inexperienced trainees have a higher tracheal intubation failure rate than experienced clinicians.\(^3\)\(^,\)\(^6\) In addition, complications associated with tracheal intubation increase as the number of repeated laryngoscopic attempts increases.\(^3\)\(^-\)\(^9\) Thus, proper laryngoscopy performance is critical so that the number of intubation attempts is reduced or the first intubation attempt is successful as much as possible.\(^9\)

As attending emergency physicians, we had observed that even well-performing junior physician trainees sometimes have trouble carrying out laryngoscopy and tracheal intubation. These trainees require a relatively long time to perform a successful intubation at the first attempt. Sometimes, they have to make several attempts because of repeated failed intubations, even for patients with normal airways. Nurses only hand a size 4 curved blade, instead of a size 3, to trainees. As a result, trainees may insert the blade too deeply, visualize the proximal esophagus by lifting the entire larynx, and attempt to find the vocal cords without realizing that the laryngoscopy is not proceeding well. Proximal esophagus visualization is a common problem that can occur during laryngoscopy,\(^1\)\(^0\) which can have fatal consequences for the patient, unless the clinician promptly realizes this error and corrects it. The use of size 4 blades might be more frequently associated with the incidence of proximal esophageal visualization than the utilization of size 3 blades because the former is longer than the latter. However, the effect of blade size on the outcomes of intubation performed by clinicians with little clinical experience remains to be elucidated.

The present study aimed to investigate whether the blade size of the curved laryngoscope affects the intubation performance of incoming interns. Therefore, we compared the time to successful intubation (TSI), success rate, and proximal esophageal visualization or esophageal intubation incidence rates between interns using size 3 and 4 curved blades.

2. Methods

2.1. Study population

Incoming interns who participated in a 1-day boot camp at the Catholic Medical Center in South Korea were enrolled in this study. These incoming interns had graduated from the medical graduate school and passed the Korean Medical Licensing Examination, including clinical skills assessment, and were about to start working as clinicians at the Catholic Medical Center. Overall, they had experience in performing intubation on a manikin but had little or no clinical experience, except for that gained during the clerkship period. This course was provided for incoming interns to help them develop competent clinical skills and practice these skills. Interns who had performed >10 tracheal intubations on patients using a conventional laryngoscope or >30 intubations on a manikin or did not wish to participate were excluded from the study.

2.2. Study design and settings

This randomized controlled manikin study used a parallel design with 1:1 allocation ratio and was conducted in a simulation center of the Catholic University of Korea. The study protocol (HC 14EISI0006) was approved by the Institutional Review Board of the Bucheon St. Mary’s Hospital, The Catholic University of Korea, Bucheon, Korea, on January 28, 2014. An overview of the study was provided on the day of training, and written informed consent was obtained from the study participants. Subsequently, the participants were randomly assigned to either the size 3 or 4 curved blade group.

The participants in each group performed tracheal intubation independently in 2 separate spaces, with each space provided with either size 3 or 4 curved blades (Welch Allyn Inc., Skaneateles Falls, NY). In addition, all necessary materials needed for tracheal intubation were identical, and a similar environment was created in the 2 spaces. A manikin (Laerdal Airway Management Trainer; Laerdal Medical, Stavanger, Norway) with no other manipulations was set up on a hospital bed, and endotracheal tubes (internal diameter, 7.5 mm), bag–valve–masks, and malleable stylets were prepared.

The group assignment was randomly determined by drawing lots. A statistician independently generated the random code and created lots based on the code. The participants were assigned to a group by directly drawing lots out of an opaque document envelope. The lots were coded so that both the participants and assessors were blinded to the group assignment.

After randomization, all participants went to one of the spaces based on their assigned group and performed a tracheal intubation using the corresponding laryngoscope. All participants were instructed to assume that they were in an emergency situation and must perform each tracheal intubation as fast as possible. A trained assistant who was blinded to the study objective modified a stilette tracheal tube into a straight-to-cuff shape before the intubation attempt. Once the intubation started, the assistant removed the malleable stylers and performed ventilation using a bag–valve mask at each intubation attempt.

2.3. Data collection and outcome measures

The primary outcome was the TSI, whereas the secondary outcomes were the first-pass and overall success rates, incidence of intubation attempts, self-reported proximal esophageal visualization, and esophageal intubation incidence rate. The TSI was defined as the time from the passing of the laryngoscope’s tips on the manikin’s teeth to the inflation of the artificial lungs using the bag–valve–mask. The first-pass success rate was defined as the rate of success at the first intubation attempt, whereas the overall success rate was defined as the rate of successful intubations within 120 seconds without accidental esophageal intubation. Failed intubations referred to attempts that did not result to a successful tracheal intubation within 120 seconds or led to recognized or unrecognized esophageal intubations. An attempt was defined as a single insertion of the device past the teeth.

The trained assessors who were blinded to the study’s purpose used a stopwatch to measure the time taken to perform a tracheal intubation. Subsequently, they recorded whether the artificial lungs were successfully inflated or not and also counted the number of intubation attempts. A post-study survey was administered to all participants to examine their baseline characteristics, including their experience in performing tracheal intubation. Subsequently, a post-study survey was conducted following intubation to check for proximal esophageal visualization.

2.4. Sample size estimation

The present study used a parallel design to compare the outcomes of tracheal intubation performed by incoming interns when 2 different sizes of curved blades were used. To estimate the required sample size, a power study that included 20 inexperienced interns was conducted in an environment that was the same as that of the present study. The means and standard deviations...
of the TSI were 16.85 ± 5.76 and 19.49 ± 7.71 seconds when using Macintosh laryngoscope size 3 and 4 curved blades, respectively. Under the assumptions of α = .005 and statistical power = 80%, the minimum sample size requirement was 210. With the consideration of a 5% dropout rate, the final sample size was determined to be 221.

2.5. Statistical analysis
All analyses were performed on a modified intention-to-treat basis. Participants who dropped out before the primary outcome could be measured were withdrawn from the analysis. The baseline characteristics and experiences of the participants were analyzed using descriptive statistics. The results were presented as frequencies and percentages for categorical variables and medians and interquartile ranges for continuous variables based on the normality of the data distribution. We used the Mann–Whitney U test to analyze the TSI and number of attempts to achieve successful intubation. In contrast, the Chi-square test was utilized in the analyses of the first-pass and overall success rates and proximal esophagus visualization and esophageal intubation incidence rates. All statistical analyses were performed using the SAS software (version 9.12; SAS Institute, Inc., Cary, NC). A 2-tailed value of P < .05 was considered statistically significant.

3. Results
A total of 221 incoming interns were randomly assigned to either the size 3 (n = 111) or size 4 (n = 110) curved blade groups (Fig. 1). Of these interns, 219 (111 in the size 3 blade group and 108 in the size 4 blade group) were included in the analysis, but 2 were excluded; 1 intern did not participate in the study and the other was lost to follow-up. No differences in the baseline characteristics, including age [size 3: 28 (26–31), size 4: 28 (26–30); P = .99], male sex [size 3: 54/111 (48.6%), size 4: 61/108 (56.5%); P = .28], and experience were observed between the 2 groups (Table 1). All participants had at least a 1-time experience in performing tracheal intubation on a manikin, and approximately 45% of the participants had experienced performing tracheal intubation on patients.

The size 3 curved blade group showed shorter TSI than the size 4 curved blade group [25.0 (21.0–35.0) vs 36.5 (24.0–80.5) seconds, P < .001] (Fig. 2). Table 2 summarizes that the size 3 curved blade group demonstrated higher first-pass and overall success rates than the size 4 curved blade group [size 3: 95/111 (85.6%), size 4: 72/108 (66.7%), P = .001; and size 3: 100/111

| Table 1 Baseline characteristics for each group. |
|-----------------------------------------------|
|                                           | Size 3 (n = 111) | Size 4 (n = 108) | P       |
| Age, y                                      | 28 (26–31)       | 28 (26–30)       | .99     |
| Sex, male                                   | 54 (49.6)        | 61 (55.5)        | .34     |
| Experiences, n                              | 110              | 111              | .34     |
| Manikin                                     | 54 (49.6)        | 61 (55.5)        | .34     |
| None                                        | 0                | 0                | .34     |
| 1-10                                        | 67 (60.4)        | 58 (53.7)        | .28     |
| 11-30                                       | 44 (39.6)        | 50 (46.3)        | .28     |
| Mankind                                     | 61 (55.0)        | 60 (55.6)        | .28     |
| None                                        | 0                | 0                | .28     |
| 1-10                                        | 50 (45.0)        | 48 (44.4)        | .28     |

Values are median [interquartile range (range)] or number (proportion).
(90.1%), size 4: 82/108 (75.9%), \( P = .005 \), respectively] (Table 2).
In addition, the incidence of intubation attempts was significantly lower for the size 3 curved blade than for the size 4 curved blade [1 (1–1) vs 1 (1–2); \( P = .001 \)] (Table 2). Meanwhile, the size 4 curved blade group displayed higher self-reporting proximal esophageal visualization and esophageal intubation incidence rates than the size 3 group [size 3: 8/111 (7.2%), size 4: 33/108 (30.6%), \( P < .001 \); and size 3: 11/111 (9.9%), size 4: 26/108 (24.1%), \( P = .006 \), respectively] (Table 3).

4. Discussion

Our study aimed to investigate whether the size of the curved blade laryngoscope affects the outcomes of intubation performed by a novice clinician. The size 4 curved blade group demonstrated longer TSI, lower first-pass and overall success rates, and higher proximal esophageal visualization and esophageal intubation incidence rates than the size 3 curved blade group. These findings indicate that the outcomes of intubation performed by novice trainees may be affected by the blade size used. Furthermore, the fact that the participants from the size 4 curved blade group showed higher proximal esophagus visualization and esophageal intubation incidence rates and longer TSI than those from the size 3 curved blade group suggests that novice trainees do not fully understand the upper airway anatomy and do not have the skills to correct their mistake when they fail to find the anatomical landmarks in the upper airway.

Most clinicians prefer a Macintosh laryngoscope with a curved blade and typically use a size 3 or 4 blade during laryngoscopic orotracheal intubation on adult patients because it facilitates easy control of the tongue. In terms of the blade size choice, some clinicians mainly utilize size 3 blades and argue that the use of size 4 blades is necessary only in patients who are overweight or have a very long thyromental distance.\(^{[10]}\) Other clinicians claim that size 4 blades are more suitable for tracheal intubation than size 3 blades considering the distance between the upper incisor and hyoid bone.\(^{[11]}\) Furthermore, some clinicians recommend the use of a size 4 blade first in all adult patients given that the vertical flange height is similar between size 3 and 4 blades.\(^{[12]}\) Generally, experienced clinicians prefer the use of a specific blade size when performing tracheal intubation on adult patients, although they do not have a problem in performing intubation even when they are handed a differently sized blade. However, in the present study, we found that novice clinicians performing intubation showed better performance with the use of a size 3 curved blade than a size 4 curved blade. The outcomes of tracheal intubation are influenced by interactions between patient factors, clinical settings, and clinician skills.\(^{[13]}\) In addition, clinicians should acquire cognitive, psychomotor, and affective skills relevant to airway management to perform tracheal intubation well.\(^{[14]}\) This study compared conventional laryngoscopes with similar shapes but different lengths. Thus, these devices were not completely different, and the laryngoscopic approach was identical. Hence, the present findings reflect differences in the clinicians’ experiences and skill levels. In particular, considering that the size 4 curved blade group displayed a higher proximal esophagus visualization incidence rate than the size 3 curved blade group, the participants appeared to lack cognitive understanding of the upper airway anatomy, which is necessary for a successful tracheal intubation.

In general, textbooks and conventional airway management trainings recommend the targeting of the vocal cords when performing tracheal intubation. However, they seldom mention the importance of the 3-dimensional anatomical structure of the larynx. The larynx inlet is an oblique circular opening, and the boundary is formed superiorly by the epiglottis, bilaterally by the arytenoid folds, and inferiorly by the arytenoid cartilage (i.e., posterior cartilage) and interarytenoid notch. The vocal cords are deeply located in the larynx and lie inferior to the larynx inlet. Thus, the vocal cords are the ultimate destination when performing direct laryngoscopy and tracheal intubation, but to a limited extent. However, the vocal cords are generally the only landmark used by novice clinicians, which explains their struggle in finding this landmark during laryngoscopy. Even when the laryngoscope blade has been inserted too deeply, inexperienced clinicians will sometimes try to displace the larynx anteriorly to look for the vocal cord in the proximal esophagus without recognizing that an esophageal laryngoscopy has been performed. Thus, the recognition of the posterior cartilage and interarytenoid notch as the anatomical distinctions between the larynx and esophagus is important.\(^{[15]}\)

In addition to the recognition of the posterior anatomical landmarks of the larynx, novice clinicians should progressively
visualize the anatomical landmarks during laryngoscopy. Proximal esophagus visualization can be prevented only if the clinician performs intubation by sequentially confirming that they have identified the epiglottis, posterior cartilage, and interarytenoid notch while advancing the laryngoscope and exposing the vocal cords. The esophagus is a cylindrical tube with no surrounding structures. It is located immediately posteriorly to the larynx, and its color is similar to that of the larynx, which easily causes novice clinicians to confuse it with the latter structure. The esophageal surface of the larynx is distinguishable from the larynx because it is convex posteriorly in both the sagittal and transverse planes. However, considering that rapid identification of the differences between the esophagus and larynx based on the shape is difficult when any laryngeal landmark is not confirmed, clinicians should remove the laryngoscope and advance it again while sequentially confirming the landmarks.

The incoming interns who participated in the study received traditional training on how to perform intubation using mainly a manikin, and some interns received intubation training during their clerkship period. In such traditional teaching settings, only the trainee can see the larynx during laryngoscopy, and the instructor can only provide limited direct and subtle feedback. Thus, video-based laryngoscopy is believed to be an excellent approach to training novice clinicians. The outcomes of direct orotracheal intubation performed by novice clinicians using video laryngoscopy enhances their recognition of the airway anatomy and skills in handling standard Macintosh laryngoscopes. The additional advantages of the training based on video laryngoscopy include the increased success rate, reduced TSI, and better learning curve. Accordingly, this approach is highlighted as an educational tool to augment training using a manikin. Thus, video-based laryngoscopy is believed to be an excellent approach to improving the novice clinicians’ recognition of the airway landmarks and training them on progressive visualization.

This study has several limitations to consider when interpreting the results. First, the participants’ past experiences with regard to the use of size 3 and 4 curved blades were not examined. We could not survey how many times participants had previously used each blade, because they did not remember the number of experiences owing to the similar shape of the blades. Hence, the present findings may have been biased because the participants may have more experience with the use of size 3 than size 4 curved blades. However, all participants had weak intubation experience before the trial, which can limit the effect of this methodological weakness. In addition, if the participants clearly recognized the upper airway anatomy and sequentially confirmed the landmarks like an experienced clinician, no significant differences in intubation performance would have been observed regardless of the experience with each blade size owing to the identical laryngoscopic approach. Second, this study used only 1 manikin, which is not a perfect substitute for humans. The size and shape of a manikin model also does not represent those of all clinical encounters in emergency situations, although we used the best available manikin, which was already evaluated and had also been used in the previous tracheal intubation-related studies. However, this is a kind of exploratory study proposing a hypothesis of whether the size of the curved blade laryngoscope affects the outcomes of tracheal intubation performed by novice clinicians in a controlled setting, where the only difference between groups is the blade size. Thus, we chose 1 manikin and considered it to be adequate for the study on the tracheal intubation through appropriate anatomical recognition of the upper airway. Nevertheless, there might be limitations in generalizing the results to the general patient population, because we used only 1 manikin. Further studies with patients in real situations are needed. Third, this study did not use a crossover design. It would be the best study design, considering that it minimizes the potential for confounding because each participant serves as his or her own control. However, because this study was conducted within a 1-day boot camp dealing with many procedures and skills, we could not choose a crossover study design considering the washout period due to a time constraint. Although it is not a crossover study, as an exploratory study, a randomized manikin study with a parallel design would be desirable to investigate the effect of the curved blade size on the outcomes of tracheal intubation in a controlled setting. Fourth, all participants were incoming interns of a medical center in an Asian country. The intubation performance of novice clinicians from other countries may not be affected even when they use a size 4 curved blade. Orotracheal intubation may not even be an essential skill for such novice clinicians as those enrolled in this study. Thus, the generalization of the study findings to other populations would be difficult. However, this study demonstrated that novice clinicians may not recognize the importance of anatomical landmarks and progressive visualization, which are critical in tracheal intubation, thus suggesting the need to address these issues during training.

5. Conclusion

The use of size 3 curved blades resulted in shorter TSI and higher tracheal intubation success rates among incoming interns at a boot camp of a medical center than that of a size 4 curved blades. The outcomes of direct orotracheal intubation performed by novice clinicians may be influenced by the blade size, which may be attributed to the lack of understanding of the upper airway anatomy and sequential identification of anatomical landmarks during tracheal intubation. Increased emphasis should be placed on key anatomical landmarks (i.e., the epiglottis, posterior cartilage, interarytenoid notch, and vocal cords) and progressive visualization for tracheal intubation during airway training for novice clinicians.

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Author contributions

JHK conceived the study. JHK, YMK, and SWK designed the study. JHK, YSC, SJL, and SWK collected and managed the data. JHK and SWK analyzed and interpreted the results. JHK and SWK drafted the manuscript, and JHK, YMK, YSC, and SJL substantially contributed to its revision. JHK takes responsibility for the paper as a whole.

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