Comparison of C-MAC® video laryngoscope versus GlideScope® in placement of double lumen Endotracheal (DLT) tube in a manikin

Introduction

Thoracic procedures involving one lung ventilation (OLV) present a special challenge to anesthesia teams who must assure adequate ventilation and oxygenation while providing a stable lung field for surgery. Although not mandatory for all thoracic procedures, OLV almost always improves access to the operation field which expedites the surgical process. To accomplish OLV, anesthesiologists often use a double-lumen endotracheal tube (DLT) (1, 2). When compared to standard single lumen tubes, the DLT has a larger diameter, longer length, and more rigid structure. These factors may make intubation with DLT’s much more difficult for anesthesiologists in both, normal and difficult airways, which increases the overall morbidity and mortality risk due to upper airway trauma and post-operative complications to the patient (4, 5, 6, 7).

Traditionally, direct Macintosh laryngoscopes have been used to place DLT. However, often incomplete view of the glottis during direct laryngoscopy significantly increases the difficulty and duration of DLT placements, hence increasing risks of hypoxia and trauma to the patient (8, 9, 10).

To address the need for easier and safer tracheal tube placement, there have been several different types of video laryngoscopes developed that may aid in DLT placements. GlideScope® (Verathon Inc., Bothell, WA, USA) is a video-assisted laryngoscope in which the vocal cords are indirectly viewed through an optical or video apparatus. GlideScope® has demonstrated their device’s effectiveness over direct laryngoscope in difficult airway intubations with standard single lumen tubes by having a higher success rate and less tissue damage (11, 12). The C-
MAC® video laryngoscope (Karl Storz GmbH & Co. KG, Tuttlingen, Germany) is another video-assisted laryngoscope. The C-MAC®’s blade has an identical shape as Macintosh 3 blade, but with camera attachment allows for both direct and indirect view of the glottis. C-MAC® has also demonstrated higher success rates of tracheal intubation compared with direct laryngoscopy in difficult airway patients (13, 14, 15). However, the effectiveness of these devices when placing a double-lumen tube has not been clearly defined and remains unclear.

The aim of this study was to compare the efficiency in double lumen (DLT) endotracheal tube placement using two different video laryngoscopes, C-MAC® and Glidescope®, and a traditional Macintosh laryngoscope in a manikin. The manikin used for this study (Laerdal) received good rating for airway training device, especially in double lumen tube intubation (22), and found to be a good alternative airway training device for fresh frozen cadavers models (23). Efficiency was measured by the following: time required to perform a successful tracheal intubation, the success rate with first attempt and number of attempts. Primary outcome of the study was to investigate the differences in the intubation efficiency amongst three types of laryngoscope as assessed by the aforementioned measurements. Furthermore, in order to investigate if levels of training and experience of the anesthesiologist affects efficiency in placing the DLT, anesthesia residents, fellows and staff physicians were identified and participated in the study. Thus, secondary outcome was the difference in efficiency depending on the level of the anesthesiologists’ training and experience.

Methods

The initial study protocol was approved by the Institutional Research Board of the University of Iowa with written consent waived to enroll residents, fellows and staff anesthesiologists in the Department of Anesthesia at the University of Iowa Hospitals and
Clinics. The faculty recruitment was limited to those with direct intubation experience in the past two years. Participants were identified on their stages/years of training as an anesthesiologist and familiarity with laryngoscope devices being tested.

**Protocol**

Each participant was given a written description of the study and its purpose as well as verbal instructions on study protocol. They were asked about their familiarity with all three devices. If they were not familiar with a particular device, then they were given time to perform manikin intubation with single lumen tube with the inexperienced devices until they felt comfortable with the device.

Every participant intubated the manikin once with each device leading to a total of three intubations. Three devices used were The C-MAC® video laryngoscope (Karl Storz GmbH & Co. KG, Tuttingen, Germany), GlideScope® (Verathon Inc., Bothell, WA, USA), and Macintosh 3 blade. The manikin used was Laerdal Head Assembly, intubation with lungs, adult male model. For all three devices, the same Covidien Mallinckrodt left-sided 37-Fr double lumen endobronchial tube was used with GlideScope® specific stylet. The testing protocol included a randomized crossover design with the order of devices used to intubate the manikin being randomized. There were six possible permutations for the order of device used which were determined by using a Latin square design. Participants were assigned to one of six different groups immediately prior to the start of the study.

**Measurement of DLT Intubation**

Participants were allowed to setup the room, such as positioning the device on the table and lubricating the DLT and its stylet, as they would in their own practice. After the setup, the timer started when participants grabbed either the device or the DLT. They were instructed to
place the DLT through the vocal cords, but did not need to place or position the tube to the carina and achieve one-lung isolation. Once the participant believed that the DLT passed through the vocal cords, then the stylet was taken out and an ambu bag was connected to the DLT. They were instructed not to cuff the balloon on the DLT and to pump the ambu bag. If the lungs inflated, then the timer stopped as they reached an endpoint of the study for having a successful intubation attempt. This process was repeated with two other devices. Participants were allowed to have an assistant assist with the following: removing the stylet, handing the ambu bag to the participant, and applying cricoid pressure, if needed.

Participants were informed in advance that successful placement of the DLT through the vocal cords and the duration to complete successful tracheal intubation were being assessed in this study. A failed intubation attempt was defined by having the DLT placed in the esophagus.

Statistical analysis

All statistical analyses were performed on data collected using IBM’s SPSS statistics program. Mean, median, range, interquartile range, standard deviation and standard error were obtained on the duration for successful intubation in all three devices. Kolmogorov-Smirnov test was performed to assess normality of the data. Through Kolmogorov-Smirnov normality test, it was found that the distribution of the time to complete successful intubation for each group was not normal. The study used median values to analyze data due to skewed distribution of intubation time in all three devices. Therefore, the Kruskal–Wallis one-way analysis of variance by ranks was performed to analyze the data. This non-parametric method analysis was used to compare all three independent samples (duration of successful intubation time in three different devices) for its significance. Furthermore, the Mann–Whitney U test was performed. This non-parametric statistical hypothesis test was used to assess the significance of two independent
sample’s values (i.e. duration of successful intubation time in C-MAC® vs. GlideScope®). The Bonferroni t-test was performed to address Bonferroni inequality when comparing more than two samples. The $\alpha$-error level for all analyses were set as $P<0.05$.

Results

There were total of 95 anesthesiologists who participated in the manikin intubation of the study (~90% of the department). Age ranged from 25 to 65 years old and 26 out of 95 were female participants. Out of 95 participating anesthesiologist there were 12 CA – 1, 15 CA – 2, 10 CA – 3, 3 fellows, 49 faculty, and 6 faculty with cardiothoracic training. There were only two participants who were not familiar with one or more devices. Their times, however, were within the quartile range and were not outliers.

Times of intubation for the three devices are shown in Table 1. The mean values for the three laryngoscopes were as follows: Macintosh 3 blade time was $20.68 \pm .95$ seconds, C-MAC® time was $18.66 \pm .77$ seconds, and GlideScope® time was $36.11 \pm 2.67$ seconds.

There were statistically significant differences in the median duration of successful intubation in two groups of comparisons: C-MAC® vs. GlideScope® ($p = 0.0001$) and Macintosh 3 blade vs. GlideScope® ($p = 0.0001$) in that intubations with Macintosh 3 blade and C-MAC® were faster than the GlideScope. However, there was no statistically significant difference in duration of successful intubation between Macintosh 3 blade and C-MAC® ($p = 0.125$).

There were two failed first attempt DLT placements using the Macintosh 3 blade, whereas no failed DLT placements in C-MAC® and GlideScope® out of 95 participants. However, participants with failed first attempts were able to recognize the misplacement of DLT and were able to successfully place the DLT within two minute window. The two failed attempts
resulted from anesthesia trainees. Failures to intubate with Macintosh 3 laryngoscope have been reported in other previous studies as well. Lin et al showed that over 20% of the DLT intubation with Macintosh 3 laryngoscope took two or more attempts (10). Enomoto et al demonstrated that there was 11% failure to intubate single lumen tube with Macintosh 3 laryngoscope (21). These two studies, however, were clinical studies as oppose to manikin based study.

**Discussion**

In this study, the primary outcome measured the successful placement of DLT through the vocal cords and ability to ventilate. Placements of DLT to the carina or one lung isolation were not measured. Since airway management has a direct effect on patient mortality and morbidity (2, 4), the time it took to place a DLT for ventilation has a significant impact on patient care. Higher success rates and faster time to intubation using the C-MAC® may be clinically significant.

The main findings of this study were that the DLT placement through the vocal cords in a manikin was significantly faster with both Macintosh 3 blade and C-MAC® when compared to GlideScope, without a statistically significant difference in time between Macintosh 3 blade and C-MAC®. There were two failed DLT placement attempts with Macintosh 3 blade. The two failed attempts resulted from anesthesia trainees. Consequently, it is possible that their intubation proficiency had an impact on first attempt failure. One of the most common causes of tracheal intubation failure may be contributed to failure to obtain an adequate view of the vocal cords. This study, however, did not ascertain if the participants have adequately identified and had vocal cords in the direct view with Macintosh 3 laryngoscope.

GlideScope® was significantly slower to intubate with, compared to Macintosh 3 blade and C-MAC® (median of 28 vs. 18 seconds). These findings may be due to several factors
including GlideScope’s® blade shape, tip of the blade placement, and user intubation technique. It was also found that the level of training did not have a significant effect as all levels of training (CA-1, CA-2, CA-3, CA-4, general staff anesthesiologist, and staff cardiac anesthesiologist) showed a trend of intubation with GlideScope® to be the slowest compare to Macintosh 3 blade and C-MAC®. Furthermore, every participant except for two was familiar and had used GlideScope® in clinical setting in the past. Therefore, unfamiliarity of the device could not have explained the differences in intubation time.

Curvature of the blade in GlideScope® is different when compared to the Macintosh 3 blade and C-MAC® which utilize the same shaped blade. The tip of the GlideScope® blade has the steeper 60-degree angulation compared to 30-degree angulation in C-MAC® (16, 18). Study participants noted they were less likely to anteriorly displace the tongue using the GlideScope® since the view of the vocal cords was already present on the monitor without anterior tongue displacement. Thus, it is possible that due to the shape of the GlideScope® blade that many participants were able to get a grade 1 view of the vocal cords without anterior displacement of the tongue. However, the problem with GlideScope® was that the majority of participants initially positioned the DLT too far posteriorly in relation to the epiglottis with suboptimal trajectory towards the vocal cords. Nevertheless, all participants were eventually able to manipulate the DLT to place it into the vocal cords. This phenomenon may be explained by several factors including: the shape of the GlideScope® blade, lack of anterior displacement of the chin resulting in suboptimal alignment of pharyngeal axis and laryngeal axis (17), and/or the placement of the tip of GlideScope® blade.

Our study has found that the majority of participants placed the GlideScope® blade posteriorly to the epiglottis to view the vocal cords. There were few participants who placed the
tip of the GlideScope® blade on vallecula, anterior to the epiglottis, then performed an anterior displacement of the chin to lift out the visual pathway. These participants initially positioned the DLT to have an optimal anterior trajectory towards the vocal cords making it easier and faster to place the DLT through the vocal cords.

It was noted that due to the shape of the GlideScope® blade and the camera location on the blade, when the blade was placed posterior to the epiglottis (Miller blade method), the anterior displacement of the chin was not necessary to have grade 1 view of the vocal cords. However, when the blade is placed on vallecula (Macintosh blade method), anterior displacement of the chin was necessary to get the grade 1 view of the vocal cords. It is inferred that anterior displacement of the chin creates an optimal alignment of oral, pharyngeal, and laryngeal axis for the DLT to be inserted through the vocal cords (17). The GlideScope® manual does not specify where the tip of the blade should be placed. The manual states that “with the laryngoscope inserted, look to the monitor to identify the epiglottis, then manipulate the scope to obtain the best glottic view,” (16) and the GlideScope® “may be used to produce a Macintosh indirect lift of the epiglottis, or Miller lift” (16). Therefore, longer duration of intubation of DLT with GlideScope® should be not considered as a user error when the tip of the GlideScope® blade is placed posteriorly to the epiglottis and the chin is not optimally lifted.

The use of manikin was one of the main limitations to this study in that the experiment was not in a clinical setting. However, previous studies have demonstrated that the use of anatomically correct manikins were able to produce dependable simulation of the clinical environments (19). Furthermore, comparing the efficacy of these three devices for DLT intubation in clinical setting may be difficult due to large sample size required for adequate
statistical power. However, information from this study may help design a future study to compare efficacy between two devices (C-MAC and Macintosh 3 Blade).

In conclusion, C-MAC® laryngoscope performs superiorly for placing a DLT in a manikin compared to GlideScope®. This may be due to the differences in shape of the blade leading to variance in alignment of three axes (pharyngeal, laryngeal and oral axis) while viewing the vocal cords on the screen. Although there were no unsuccessful attempts with the C-MAC® laryngoscope in contrast to the Macintosh 3 laryngoscope which had two unsuccessful attempts, this was not statistically significantly different. Future clinical study is needed for direct comparison between C-MAC® laryngoscope and Macintosh 3 laryngoscope to determine the advantages when performing DLT intubation.
Reference

Figures

<table>
<thead>
<tr>
<th></th>
<th>Macintosh 3 blade (n = 95)</th>
<th>C-MAC® (n = 95)</th>
<th>GlideScope (n = 95)</th>
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<tr>
<td><strong>Mean (sec)</strong></td>
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Table 1

Graph 1

P values: Mac 3 Vs. C-MAC: 0.125
C-MAC Vs Glidescope: 0.0001
Mac 3 Vs. Glidescope: 0.0001