ORIGINAL ARTICLE

Comparison of Macintosh Direct Laryngoscope with the C-MAC and Tuoren Videolaryngoscopes in Facilitating Endotracheal Intubation during Uninterrupted Manual Chest Compression: A Randomized Crossover Manikin Study

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Abstract

Background: Videolaryngoscopes (VLS) frequently provide superior views of the glottis compared with traditional direct laryngoscopy (DL), especially during unexpected difficult airways. Chest compressions during attempts to intubate the trachea make it a difficult situation. Although VLS have been compared with DL for intubation during resuscitation, there is a paucity of literature comparing VLS with integrated screen and distant screen with DL during continued manual chest compressions.

Materials and methods: This was a prospective, randomized, crossover observational manikin study. A total of 20 participants performed intubation, while manual chest compression was continuing, with each of the three devices on six occasions, but in different, randomized order. The primary outcome parameter was the total time taken for successful intubation. The secondary outcome criteria included the number of attempts, ease of intubation, and the device preference.

Results: Time taken for successful intubation and ease of intubation were significantly better with C-MAC VLS and DL as compared with Tuoren VLS (C-MAC vs Tuoren $p < 0.000$ for both; DL vs Tuoren $p < 0.001$ for time and $p = 0.021$ for ease). There was no significant difference between C-MAC and DL ($p = 1.0$ for time and $p = 0.69$ for ease). There was no significant difference with regard to the number of attempts for successful intubation with any of these devices ($p = 0.310$). C-MAC was the most and Tuoren was the least preferred device.

Conclusion: C-MAC VLS and Macintosh DL are significantly easier to use and require significantly less time to achieve successful intubation as compared with the Tuoren VLS during continued manual chest compression. Among the devices tested, C-MAC VLS was the most preferred for endotracheal intubation during uninterrupted manual chest compressions.

Keywords: Airway management, Cardiac arrest, Direct laryngoscopy, Endotracheal intubation, Videolaryngoscope.

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Highlights

Comparison of Macintosh direct laryngoscopy (DL) with the C-MAC and Tuoren videolaryngoscopes (VLS) in facilitating endotracheal intubation during uninterrupted manual chest compression.

Introduction

Continuous high-quality chest compressions are vital during cardiopulmonary resuscitation (CPR) for patients in cardiac arrest. Interruptions in compressions can jeopardize perfusion to critical organs, diminishing the chances of successful resuscitation.[1–3] Recent guidelines indicate that providers can use either bag-mask ventilation or an advanced airway approach for effective airway management in any setting for adult cardiac arrest. If endotracheal intubation is the chosen strategy for airway management during CPR, it should be performed with minimal interruption to chest compressions—ideally requiring no or only a brief pause to place the tube through the vocal cords.[4,5]

Securing an advance airway while maintaining uninterrupted chest compressions can be quite challenging, even for experienced emergency physicians and intensivists. Traditional direct laryngoscopic intubation with Macintosh DL requires proper alignment of the oral, pharyngeal, and tracheal axes. This alignment becomes difficult during continuous manual chest compressions, as the rapid movement of the glottis in relation to the chest wall complicates the procedure.[6] A study by Gatward et al. demonstrated that chest compressions often delayed endotracheal tube (ETT) placement with the DL, frequently resulting in interruptions lasting longer than 10 seconds.[7]

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Videolaryngoscopes were designed to address the limitations of traditional intubation techniques and have demonstrated effectiveness across various settings. These devices remove the need for precise alignment of the oral, pharyngeal, and tracheal axes, improving visualization and aiding tracheal intubation, particularly when the glottis is difficult to see. Recent studies suggest that VLS frequently provide superior views of the glottis compared with traditional DL, positioning them as a reliable alternative for managing both expected and unexpected difficult airways.[8–14]

We hypothesized that VLS with a Macintosh blade-like curvature, featuring either an integrated monitor (Tuoren VLS; Tuoren Medical Device India Pvt. Ltd.) or a distant monitor (C-MAC VLS; Karl Storz Endoscopy India Pvt. Ltd.), will decrease the time needed for endotracheal intubation and enhance success rates compared with the standard Macintosh DL when intubation is performed during ongoing chest compressions.

This study was aimed at comparing the performance of Macintosh DL with Tuoren VLS and C-MAC VLS in facilitating endotracheal intubation during uninterrupted manual chest compressions in a simulated setting.

Materials and Methods

This was a prospective, randomized, crossover, observational, simulation study. After obtaining approval from the Institutional Review Board, 20 participants were enrolled for this study, consisting of 10 anesthesiology consultants and 10 senior residents. The eligibility criteria for the participants included having performed over 50 successful tracheal intubations in patients using Macintosh DL and having experience with at least 20 successful VLS-guided tracheal intubations. Written informed consent was obtained from all participants before their inclusion.

The participants were oriented to both the VLS and the manikin used in the study (ACLS Trainer, Laerdal Medical India Pvt. Ltd.). They were briefed on the practical use of the C-MAC and Tuoren VLS, as well as the proper handling of the styletted ETT. An instructor, an anesthesiologist/intensivist with over 15 years of experience in anesthesiology and intensive care, demonstrated both the correct placement of a styletted ETT in trachea and its misplacement in esophagus. Participants were instructed to follow the "look-in, look-out; look-in, look-out" approach when using the two VLS. This look-in, look-out; look-in, look-out approach begins by inserting the VLS blade into the mouth of the manikin along the midline, with the operator looking inside the oral cavity ("look-in"). Once the tip of the VLS blade goes beyond the convexity of the tongue, the operator shifts his gaze to the monitor screen ("look-out"). The blade is then directed into the vallecula to achieve a percentage of glottic opening score of 50%. A styletted ETT is now inserted with the operator again looking inside the oral cavity ("look-in") until the ETT is beyond the VLS camera. At this point he shifts his attention back to the monitor screen outside ("look out") to guide the ETT through vocal cords.

Participants then practiced intubating the manikin with a styletted ETT (size 7.5) over the course of 1 week, 10 times with each of the three devices (both VLS and DL).

During the study, participants (consultant or resident) were chosen randomly using a computer-generated random number table. The chosen participant performed intubation with each of the three devices (Macintosh DL, C-MAC VLS, and Touren VLS) on six occasions, but in different, randomized order. To ensure this, each participant was given six sealed envelopes containing different combinations for using these devices (DCT, DTC, CDT, CTD, TDC, TCD; where D = direct laryngoscopy with Macintosh blade size 3, C = C-MAC VLS with blade size 3, and T = Tuoren VLS with blade size 3).

The participant opened one of the envelopes on a given day and attempted three intubations on a manikin with a 7.5-mm styletted ETT, based on the order specified in the envelope she/he had opened. Intubations were performed while chest compressions were going on at a steady pace of 110 compressions/minute using a metronome. The manikin was placed on table of appropriate height to ensure optimal intubation conditions, and the person performing chest compressions used a footstool to be at the right height.

To optimize the conditions for laryngoscopy and intubation, airway of the manikin, tracheal tubes, and intubation stylets were thoroughly lubricated with a lubricant recommended by the manufacturer. An assistant was provided to help prepare the ETT and stylet, inflate the ETT cuff after intubation, and initiate mechanical ventilation with a resuscitator bag. This was done to ensure that the intubation time reflected only the participant's ability to achieve proper visualization and to place the ETT in trachea. The assistant did not assist the participants with laryngoscopy. All participants underwent individual evaluations, and their peers were not allowed to observe.

After completing intubation with the first device, the participants performed intubation with the second device and then the third device (as decided by randomization) under similar circumstances with short breaks in between two attempts to get ready with that device.

The following observations were made:

- Time for successful intubation: The time taken during a successful attempt (1st, 2nd, or 3rd) from the moment the participant picked the device (DL or VL) to effective manikin ventilation with a resuscitator bag, confirmed by visible chest rise.
- Number of attempts: A new attempt was counted if the participant had to pull the ETT out of the patient's mouth. A maximum of three attempts were permitted.
- Ease of intubation: After completing each intubation, participants were asked to rate the ease of intubation on a scale of 1–5 (1 being easy and 5 being impossible).
- Device preference: At the end of attempts with all three scopes, participants rated the devices in descending order of preference.

Failed intubation was defined as either not been able to intubate trachea after three attempts or performing an esophageal intubation. The study period concluded when:

- The participant successfully passed the ETT into the trachea, or
- All three attempts were exhausted, or
- The participant performed an esophageal intubation.

The primary outcome parameter was the time required for successful intubation. The secondary outcome criteria included the number of intubation attempts, ease of intubation, and the device preference.

Data were analyzed using IBM Statistical Package for the Social Sciences version 29.0. Categorical variables were presented as frequencies and percentages, while continuous variables were presented as mean ± standard deviation. Kruskal–Wallis test was employed to assess differences among three groups: DL, C-MAC VLS, and Tuoren VLS. *Post-hoc* pairwise comparisons were conducted

Table 1: Comparison of intubation performance across DL, C-MAC VLS, and Tuoren VLS

Variables	*DL*	*C-MAC VLS*	*Tuoren VLS*	*p-value*
Time for intubation (sec)	14.05 ± 1.89	13.70 ± 1.27	16.09 ± 1.55	<0.001
Number of attempts	1.02 ± 0.07	1.03 ± 0.82	1.05 ± 0.09	0.310
Ease of intubation	1.26 ± 0.32	1.05 ± 0.13	1.66 ± 0.47	<0.001

Table 2: Pairwise comparison of DL,C-MAC VLS, and Tuoren VLS for variables found significantly different during comparison across these devices (presented in Table 1)

Variables	*DL vs C-MAC*	*DL vs Tuoren*	*C-MAC vs Tuoren*
Time for intubation (sec)	1.0	0.001	0.000
Ease of intubation	0.69	0.021	0.000

Table 3: Participant preferences for intubation devices: C-MAC VLS, DL, and Tuoren VLS

Device preference for intubation	*First n (%)*	*Second n (%)*	*Third n (%)*
C-MAC VLS	16 (80.0)	4 (20.0)	0 (0.0)
Macintosh DL	4 (20.0)	16 (80.0)	0 (0.0)
Tuoren VLS	0 (0.0)	0 (0.0)	20 (100.0)

when comparison of all three groups showed significant differences. Statistical significance was defined as $p < 0.05$.

Results

The median age of the participants was 39 years. Each participant performed intubation using all three devices—Macintosh DL, C-MAC VLS, and Touren VLS on six separate occasions.

Time of successful intubation was significantly more with Tuoren VLS compared with both C-MAC VLS ($p < 0.000$) and DL ($p < 0.001$), while the C-MAC VLS and DL performed similarly in this regard ($p = 1.0$) (Tables 1 and 2). Both C-MAC VLS ($p < 0.000$) and DL ($p = 0.021$) were significantly easier to use than Tuoren VLS but there was no significant difference between C-MAC VLS and DL ($p = 0.69$). There was no significant difference with regard to the number of attempts for successful intubation between three devices ($p = 0.310$) (Table 1).

The C-MAC VLS was the most preferred device while the Tuoren VLS was consistently the least preferred device (Table 3).

Discussion

The dynamic nature of the airway during chest compressions and limited ability to pre-assess the airway can complicate visualization and access, making it difficult to achieve successful intubation.[3–5] In the present study, we compared the performance of two VLS having Macintosh blade-like curvature, Tuoren VLS (equipped with an integrated monitor) and C-MAC VLS (equipped with a distant monitor), with Macintosh DL in facilitating endotracheal intubation during uninterrupted manual chest compressions in a simulated setting.

We found that participants took significantly longer time to intubate using the Tuoren VLS compared with both the C-MAC VLS ($p = 0.000$) and the DL ($p < 0.001$). Similarly, Tuoren VLS was found to be significantly more difficult to use than C-MAC VLS ($p = 0.000$) and DL ($p = 0.021$) (Tables 1 and 2). We feel that there were a few reasons for this increased time and feeling of more difficulty with Tuoren VLS. First, even though the operator needs to look inside the mouth when the Tuoren VLS blade is being introduced into the mouth, he wants to keep the integrated, adjustable monitor on the Tuoren VLS handle at an angle that would offer a well-focused picture. And when it is time to shift the gaze out, once the tip of the blade has negotiated the convexity of the tongue, the handle has been straightened and accordingly the monitor has to be readjusted a little. In contrast, C-MAC VLS has a separate monitor, which does not need refocusing and while using Macintosh DL, the operator is looking inside the mouth during the whole act of visualizing vocal cords. Second, Tuoren VLS blade has a slightly more curved design compared with C-MAC blade, which requires more pronounced angulation in the styletted tube than with C-MAC, leading to more frequent adjustments to facilitate tracheal intubation. Third, the distal part of the flange of C-MAC blade is narrower (1.4 cm) than that of Tuoren VLS blade (2.5 cm), allowing easier insertion into the oral cavity. Fourth, better picture quality of C-MAC monitor and its wider viewing angle make the tracheal intubation easier as compared with Tuoren blade.

Contrary to our observations, a systematic review and meta-analysis by Sanfilippo et al. on endotracheal intubation during chest compressions in pediatric simulations mentions, as an indirect observation, that VLS with integrated monitors often perform better than those with distant monitors. They suggested that this advantage could stem from the difficulty in maintaining steady control of the VLS while shifting focus between the laryngoscope and the distant monitor, particularly during the instability of ongoing chest compressions.[14] In our study, where we were using the commonly suggested look in–look out technique during VLS, the operator's gaze had to anyway shift between mouth of the manikin and monitor for both VLS. Thus, the VLS that maintained a uniform focus on its monitor (C-MAC) outperformed the one where a change in the angle of its handle changed the focus of the image, needing slight readjustment of its monitor (Tuoren).

Based on the discussion above, it was no surprise that Tuoren VLS consistently ranked the least preferred of the three devices. Out of the other two, C-MAC VLS was the first preference in 80% cases (Table 3). Several factors contributed to this preference, including closer resemblance of the blade of C-MAC VLS with the DL blade, large screen size, and superior picture quality compared with both DL and Tuoren VLS.

We found no significant difference among the three devices with regard to the number of attempts for successful intubation ($p = 0.310$). Our results are consistent with those of Kim et al. and Min et al., who also reported no significant differences in first-pass success between VLS and conventional DL when used by experienced operators during CPR in the emergency department.[15,16] All our participants were also experienced anesthesiologists proficient in endotracheal intubation using DL.

There are a few limitations of our study. First, as a manikin-based study, it may not fully replicate the complexities of the human airway during real CPR conditions, and findings from manikin studies may not always translate directly to real-life clinical scenarios. However, due to ethical considerations, conducting a crossover study in an actual CPR setting was not feasible. The advantage of manikins is that they allow for a crossover design, providing standardized airway conditions for each participant.

Second, the number of participants was relatively small, mainly because recruitment was limited by practical constraints of a relatively small department.

Conclusion

In a simulated setting of CPR with continued manual chest compression, C-MAC VLS and Macintosh DL require significantly less time to achieve successful intubation and are significantly easier to use than Tuoren VLS, but there is no significant difference in the number of attempts required for successful intubation among all three devices. Among the devices tested, C-MAC VLS was the most preferred for endotracheal intubation during uninterrupted manual chest compressions.

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