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Comparison of the C-MAC video laryngoscope to the Macintosh laryngoscope for intubation of blunt trauma patients in the ED

Erkan Goksu [a, *], Taylan Kilic [b], Gunay Yildiz [c], Aslihan Unal [a], Mutlu Kartal [a]

[a] Department of Emergency Medicine, Akdeniz University School of Medicine, Antalya, Turkey
[b] Emergency Service, Antalya Training And Research Hospital, Turkey
[c] Kilis State Hospital, Turkey

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ABSTRACT

Objectives: We aimed to compare the performance of the C-MAC video laryngoscope (C-MAC) to the Macintosh laryngoscope for intubation of blunt trauma patients in the ED.
Material and methods: This was a prospective randomized study. The primary outcome measure is overall successful intubation. Secondary outcome measures are first attempt successful intubation, Cormack–Lehane (CL) grade, and indicators of the reasons for unsuccessful intubation at the first attempt with each device. Adult patients who suffered from blunt trauma and required intubation were randomized to video laryngoscopy with C-MAC device or direct laryngoscopy (DL).
Results: During a 17-month period, a total of 150 trauma intubations were performed using a C-MAC and DL. Baseline characteristics of patients were similar between the C-MAC and DL group. Overall success for the C-MAC was 69/75 (92%, 95% CI 0.83 to 0.96) while for the DL it was 72/75 (96%, 95% CI 0.88 to 0.98). First attempt success for the C-MAC was 47/75 (62.7%, 95% CI 0.51 to 0.72) while for the DL it was 44/75 patients (58.7%, 95% CI 0.47 to 0.69). The mean time to achieve successful intubation was 33.4 ± 2.5 s for the C-MAC versus 42.4 ± 5.1 s for the DL ($p = 0.93$). There was a statistically significant difference between the DL and C-MAC in terms of visualizing the glottic opening and esophageal intubation in favor of the C-MAC ($p = 0.002$ and $p = 0.013$ respectively).
Discussion and conclusion: The overall success rates were similar. The C-MAC demonstrated improved glottic view and decrease in esophageal intubation rate.

1. Introduction

Endotracheal intubation is the most convenient technique for securing the airway of critically ill patients. The foremost method of securing the airway in the emergency department (ED) is direct laryngoscopy (DL).[1] This method was introduced into clinical practice more than 50 years ago. With advances in technology, many video laryngoscopes have been introduced into the market and are used by Emergency Physicians (EPs). Video Laryngoscopes incorporate a camera at the tip of the blade with different blade angles, which is in contrast to DLs, which present the laryngeal view directly.

The C-MAC video laryngoscope (Karl Storz, Tutlingen, Germany) is a relatively new airway device, resembling the Macintosh blade but with the addition of a micro camera at the tip of the blade. Its resemblance to Macintosh laryngoscope makes it more user-friendly and allows the operator to use it as a direct laryngoscope when there is a malfunction in the attached camera.

Endotracheal intubations of trauma patients deserve special attention, as trauma patients are assumed to have an unstable cervical spine (C-spine) until proven otherwise. Immobilizing the neck of the patient with a cervical collar restricts mouth opening and impedes the alignment of the oral, pharyngeal and laryngeal axes. Trauma patients may have additional factors that make intubation difficult, such as blood and other secretions in the airway, facial trauma, hemodynamic instability and respiratory compromise.[2]

Various studies have shown that different video laryngoscope devices improve glottic exposure over direct laryngoscopy in

* Corresponding author.
E-mail address: erkangoksu@akdeniz.edu.tr (E. Goksu).
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controlled environments, such as the simulation center or operation room.[1] It is not clear if this finding may be translated into real emergency situations in terms of resulting in faster, easier or more successful intubations, however.[3]

The aim of the present study is to compare the performance of the C-MAC video laryngoscope (C-MAC) to the Macintosh laryngoscope for intubation of blunt trauma patients in the ED. The primary outcome measure is overall successful intubation. Secondary outcome measures are first attempt successful intubation, Cormack–Lehane (C–L) grade and indicators of the reasons for unsuccessful intubation at the first attempt with each device.

2. Methods

2.1. Study design

This prospective randomized study was conducted at an urban tertiary care facility with an annual intake of approximately 90,000 patients (May 2013 to October 2014). The ED has an accredited 4-year emergency medicine residency program. The study was approved by the institutional review board.

2.2. Study setting and population

Those patients over the age of 16, arriving at the ED due to blunt trauma requiring endotracheal intubation to secure the airway, were included in the study. Patients presenting to the ED with penetrating trauma, age under 16 and intubated before ED arrival were excluded from the study.

2.3. Study protocol

Either a C-MAC or a DL was randomly selected through the use of sequentially numbered, opaque, sealed envelopes. The data was collected by the emergency residents. The duration of intubation was measured by the nurses or paramedics preparing the intubation materials and opening the sealed envelopes. The operators were residents and attending physicians of the ED. The data pertaining to the study included the following information: patient demographics (age, sex, estimated height, estimated weight, body mass index); the postgraduate year (PGY) of the resident who initially attempted the intubation, the number of intubation attempts (an attempt was defined as an introduction of the laryngoscope into the mouth and its removal regardless of whether an ET tube was inserted); the number of operator(s) performing the procedure (in case of failed intubation); the need to switch to a different device or a different operator; the reasons for intubation failure on the first attempt (i.e. when the glottic opening could not be seen, ETT could not be directed, ETT could not pass the glottic opening, esophageal intubation, the presence of secretions and/or blood); the device(s) used; the duration of intubation (the duration of tracheal intubation was defined as the time taken from insertion of the blade between the teeth until the lungs were inflated with a bag-valve mask); the minimum oxygen saturation measured during the procedure, and; C–L grades recorded during ET intubation. At the end of each intubation, every participant graded the ease of use of each device on a 10 cm visual analog scale (VAS). ET tube placement was confirmed by traditional methods (auscultation, fogging in the tube) and $ETCO_2$ measurement. The primary intubation method was rapid sequence intubation; only those patients in cardiac arrest were intubated with no medications as and when necessary. First pass success was defined as correct placement of the ETT in the trachea in a single attempt. C-MAC blades sized 3–4 and Macintosh blades sized 3–4 were used. A stylet was used in the ETT for all intubations. The total time of tracheal intubation was documented, regardless of the number of attempts. In trauma patients, during the intubation period, a C-collar was removed and manual in-line immobilization was performed to all the patients.

3. Primary Data Analysis

The study data were analyzed in SPSS 16.0 for Windows (SPSS Inc., Chicago, Illinois, USA). Demographic and baseline characteristics were summarized as a mean ± SD for continuous variables, and as a percentage of the group for categorical variables. Non-normally distributed data are presented as medians (inter-quartile range). The normality analysis was performed with the Kolmogorov–Smirnov test. The chi-square test or Fisher's exact test, where appropriate, was used to compare the proportions. The Mann–Whitney U test was used to compare the ordinal and non-normally distributed variables. A p value of less than 0.05 was considered to indicate a statistically significant result.

For a two-sided test with a Type 1 error rate of 0.05, power-equaled 0.80 to detect a 20% difference with 60% success of ET intubation, each group required 82 patients.

4. Results

During the study period, a total of 150 patients were intubated secondary to blunt trauma. Of these 150, 75 were intubated with the DL and 75 were intubated with the C-MAC. The mean age (35 ± 15.5 years in the DL group and 39 ± 19 years in the C-MAC group), as well as ratio of males to females were similar between the groups [2 (2.7%) females in the DL group and 5 (6.7%) female patients in the C-MAC group], the exception being the postgraduate year status of the resident performing the intubation (Table 1). The main indication for endotracheal intubation was head trauma in 50 (33.3%) patients, cardiac arrest in 27 (18%) patients, multiple trauma in 8 (5.3%) patients, airway control in 27 (18%) patients, facial trauma in 5 (3.3%) patients, and low GCS in 9 (6%) patients. The median GCS of the patients in the DL group was 7,[3–11] while in the C-MAC it was 7.[3–10] In 36 (48%) patients in the DL group and 25 (33%) patients in the C-MAC group oxygen saturation was below 90%. EM attending physicians performed 11 (7.3%) tracheal intubations. 58.7% (95% CI 0.47 to 0.69) of ET intubations with the DL and 62.7% (95% CI 0.51 to 0.72) of intubations with the C-MAC were successful at the first attempt. The overall success rates were similar between the devices. First pass success did not differ in both groups (58.7% for DL vs. 62.7% for C-MAC p = 0.61). The reasons for

Table 1
Patient characteristics.

	C-MAC n = 75	Direct laryngoscopy n = 75	p-value
Mean age (years) (range)	39 ± 19	35 ± 15.5	0.185
Median BMI	24 (IQR 23–29)	24 (IQR 22–26)	0.2
Indication for intubation			
Head Trauma	30 (40%)	20 (26.7%)	
Airway control	14 (19%)	13 (17.3%)	
Low GCS	4 (5.3%)	5 (6.7%)	
Multiple Trauma	3 (4%)	5 (6.7%)	
Cardiac arrest	11 (14.7%)	16 (21.3%)	
Facial/Neck Trauma	0	5 (6.7%)	
Post graduate year			
PGY-1	2	11	
PGY-2	18	17	
PGY-3	19	15	
PGY-4	29	27	
Attending physician	7	5	
First attempt success	56 (62.7%)	44 (58.7%)	
Second attempt success	13 (17.3%)	21 (28%)	

failed intubation at the first attempt with the DL were; inability to visualize the glottic opening in 16 (21.3%) cases; inability to direct the ETT in 8 (10.7%); inability to advance the ETT between the vocal cords in 6 (8%) cases; esophageal intubation in 7 (9.3%) cases, and; inability to intubate due to secretions/blood in 11 (14.7%) cases. The reasons for failed intubation at the first attempt with the C-MAC were; inability to visualize the glottic opening in 3 (4%) cases; inability to direct the ET tube in 6 (8%); inability to advance the ET tube between the vocal cords in 2 (2.7%) cases; esophageal intubation in 0 (0%) cases, and; inability to intubate due to secretions in 7 (9.3%) cases (Table 2). Statistically, there was a significant difference between the DL and C-MAC in terms of visualizing the glottic opening and esophageal intubation in favor of the C-MAC ($p = 0.002$ and $p = 0.013$, respectively). The other parameters accounting for failed intubation in the first attempt (inability to direct the ET tube; inability to advance the ET tube between the vocal cords, and; inability to intubate secondary to secretions or blood) showed no statistically significant difference between the devices. The DL was changed to C-MAC in three cases and the C-MAC was changed to DL in 6 cases. The providers were all successful after switching from C-MAC to DL or vice versa.

The mean time required for a successful ET intubation with DL and C-MAC was 42.4 ± 51 and 33.4 ± 25 s respectively. The mean duration of intubation did not differ between the devices ($p = 0.93$).

A 10 cm visual analog scale (VAS) was recorded for the DL or C-MAC to reveal the difficulty of intubation (22 IQR (7–65) for the DL and 22 IQR (8–54) for the C-MAC). There was no statistically significant difference in the difficulty of ET intubation between the devices. C–L grade was 1 in 56 patients (37.3%), 2 in 62 patients (41.3%), 3 in 25 patients (16.7%) and 4 in 5 (3.3%) patients. The C–L groups were similar in the DL and C-MAC groups. The C–L grades 1 and 2 were grouped together as easy intubations, while the C–L grades 3 and 4 were grouped as difficult intubations. There was no statistically significant difference in terms of first attempt successful intubation between easy or difficult intubation according to grouped C–L grades.

5. Limitations

This study has several limitations. Firstly, the PGY of the operators were not equal between the C-MAC and DL group and this situation may be a limitation of this study. Furthermore, the indication for ET intubation was left open ended in the study form; that is why indications may not reveal the full spectrum. The number of intubation attempts were graded by the residents and this might cause a potential bias. Inter-rater reliability was not assessed for C–L grading. There were more cardiac arrest patients in the DL group thus making the ETT confirmation more difficult. This study included predominantly thin patients and the results of our study may not be generalized to larger patients. Finally, the number of patients participated the study was lower than we had expected. Because enrollment fell short of our targeted 164 patients, due to break down of C-MAC and the main conclusion of C-MAC did not improve overall intubation success may be a result of type 1 error.

Table 2
The reasons for failed intubation.

	C-MAC	Direct laryngoscope	P value
Inability to visualize cords	3 (4%)	16 (23, 1%)	0.002
Failure to direct the ET tube	6 (8%)	8 (10.7%)	0.83
ET tube could not be passed between the vocal cords	2 (2.7%)	6 (8%)	0.36
Esophageal intubation	0 (0%)	7 (9.3%)	0.013
Secretions	7 (9.3%)	11 (14.7%)	0.26
Switch to an other airway device	6 (8%)	3 (4%)	0.25
Switch to an other operator	8 (10.7%)	20 (26.7%)	0.013

6. Discussion

According to the results of this study, the overall success rates were similar between the devices. The C-MAC offered better glottic visualization when compared to the DL, and the C-MAC also protected against inadvertent esophageal intubation.

In a prospective study, the C-MAC (Karl Storz Video Macintosh Laryngoscope) was compared with the DL so as to rate the glottic visualization according to C–L grade. According to result of their study, the C-MAC enabled better visualization of glottic opening. In this study, 198 patients were prospectively enrolled, with 51 (26%) of the study participants being trauma patients.[4] A meta-analysis of randomized trials that compared video laryngoscopes with DL for ET intubation showed that video laryngoscopes achieve a better view of the glottis. This meta-analysis included those patients in the operating room for scheduled surgical interventions and the experienced anesthesiologists who performed the procedure.[5] In the study of Carlson et al, the video laryngoscope provided superior views of the glottic opening compared with the DL.[6] Although the change in glottis opening with the video laryngoscope and DL was not graded in the present study, we found that the visualizing of the glottic opening was more pronounced with the video laryngoscopes (23.2% with the video laryngoscopes vs. 4% with the DL). An angled camera attached to the tip of a blade may magnify the glottic view in cases where cervical immobilization is of paramount importance, such as a patient with a cervical collar in which the alignment of airway axes is a challenge.

A meta-analysis of randomized trials comparing video laryngoscopes with DLs for ET intubation showed similar success rates of tracheal intubation, while the duration of tracheal intubation was not different between the video laryngoscope and DL in the operating room for scheduled surgical interventions performed by experienced anesthesiologists. In a subgroup analysis of this meta-analysis, the video laryngoscope exhibited a significantly shorter duration of endotracheal intubation when there is a difficult airway parameter, but a longer duration for endotracheal intubation when there is no difficult intubation setting.[5] In another study, despite 5 different video laryngoscopes and the ET intubations having being performed in the OR, Carlson et al revealed that the video laryngoscope did not improve the overall rate of intubation success. For difficult airways, however, the video laryngoscope decreases the time required for intubation, and they also showed that all types of video laryngoscopes performed similarly.[6,9] In another study, comparing the Glidescope (Verithon, Bothell, WA) and C-MAC, first attempt pass and overall successful intubation performance were similar.[10] Our findings on first attempt success and overall success rate conform to those previous studies in which the procedures are performed in controlled environments, such as in the operation room.[11] However, some studies found that the C-MAC was associated with more successful intubations compared to the DL, both in terms of ultimate success and first-attempt success.[1] In another study by Sakles et al, they compared the video laryngoscope and the DL use in patients with difficult airway characteristics and found that the video laryngoscope had a greater first pass success than the DL, and that the video laryngoscope offered higher odds of first pass success for patients with difficult airway characteristics.[12] This contrasts with our study; we could not find such a difference in terms of overall intubation success and first pass intubation success. In the study of Sakles et al, the video laryngoscope and DL were compared in trauma and medical cases; this may be the source of the discrepancy between other studies and our findings.[12]

Mosier et al showed that, in a medical intensive care unit, first attempt success and ultimate success of PGY 1 to 3 were not statistically significant between the DL and video laryngoscope, but in the PGY4+ (attending physician/fellow) first attempt success and ultimate success of the video laryngoscope and DL were statistically significant.[7] In another surgical ICU study, Noppens et al compared the data of 274 intubations: they revealed that first attempt success rates between the DL and C-MAC (80% vs. 88%) were not statistically significant, and the operators in this study were junior, senior and attending level anesthesia-trained physicians.[13] Although we did not compare the data pertaining to the difficult airway predictors (obesity, short neck, small mouth, large tongue), the study of Mosier et al did focus on difficult airway predictors: they have found that the C-MAC was superior to the DL in patients with at least one predictor for a difficult airway.[7]

Our Emergency residency program lasts 4 years: in the study of Sakles et al, nearly 75% of the patients were intubated by PGY2-3, whereas in our study nearly 50% of the patients were intubated by PGY3-4.[12]

It is a well-known fact that complications such as esophageal intubation may cause hypoxemia, aspiration, hypotension, dysrhythmias and even cardiac death. One important advantage of the C-MAC in our study was to prevent inadvertent esophageal intubation when compared with the DL (9.3% vs %0 $p = 0.013$). A study comparing the video laryngoscope and DL in a medical intensive care unit found that the video laryngoscope reduced the esophageal intubation rate from 12.5% with the DL to 1.3%.[7] And another study showed that the video laryngoscope reduced the rate of esophageal intubation [0.14, 95% CI 0.02–0.81 $p = 0.03$].[8]

Although glottic view is improved with the C-MAC, this was not translated into the duration of ET intubation. Multiple studies have noted a better view of the glottis with the video laryngoscope, but this improved view was not always associated with successful intubation in all patients.[2] The reason for this may be the time elapsed during eye and hand coordination, and manipulation of the ET tube into the trachea with the video laryngoscope may have balanced out with trying to find a proper glottic exposure with the DL.

The first attempt success rate of ET intubation was lower than in certain other studies.[7] There may be several reasons for this finding. First, the study population consisted of only trauma patients, and secondly, this may be secondary to use of early PGY residents. PGY-1 in our particular program roughly correlates with internship, and PGY-2 corresponds to PGY-1 in United States. PGY1-2 operators performed 30% of the ET intubations in this study. It is an accepted fact that the level of experience and training of the operator has been identified as a potential indicator of a more difficult intubation.[7] This is a particularly important issue as the providers were often trainees in EM, who are at different levels in terms of years of experience.

Although the intubation times were very similar, desaturation rates with DL was higher than C-MAC (48% vs 33%).

In the DL group, 20 of the ET intubations were left to an experienced operator. This result shows that the C-MAC is an important educational tool and also a measure of quality control. The supervising physician and residents can watch the ET intubation process throughout the procedure, allowing real-time guidance and visual confirmation of the ET tube, preventing unnecessary operator change.[4]

7. Conclusion

In conclusion, in this study in the ED, although overall success rates were similar between the study devices, we demonstrated improved glottic view and a decrease in esophageal intubation rate with the C-MAC. First attempt and overall success rates, as well as the duration of intubation with the C-MAC were at least equal to the DL in trauma patient population treatment in the ED.

Conflict of interest

None.

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