Comparison between C-MAC® video-laryngoscope and Macintosh direct laryngoscope during cervical spine immobilization

Shahir HM Akbar* and Joanna SM Ooi**

Abstract

Background: Video-laryngoscopes have gained popularity in the recent years and have shown definite advantages over the conventional Macintosh direct laryngoscopes. However, there is still insufficient evidence comparing the C-MAC® with the Macintosh for patients during manual inline stabilization (MILS).

Methods: This prospective, randomized, single blind study was carried out to compare tracheal intubation using the C-MAC® video-laryngoscope and Macintosh laryngoscope in patients during MILS. Ninety consented patients, without features of difficult airway, who required general anesthesia and tracheal intubation were recruited. Intubation was performed with either the C-MAC® video-laryngoscope or the Macintosh laryngoscope by one single investigator experienced with both devices. Various parameters which included Cormack and Lehane score, time to intubate, intubation attempts, optimization maneuvers, complications and hemodynamic changes were recorded over the initial period of 5 minutes.

Results: C-MAC® video-laryngoscope performed significantly better with lower Cormack and Lehane grades, shorter time to intubate of 32.7 ± 6.8 vs. 38.8 ± 8.9 seconds (p=0.001) and needed less optimization maneuvers. There were no significant differences seen in the intubation attempts, complications or hemodynamic status of the patients with either device.

Conclusion: The C-MAC® video-laryngoscope was superior to the Macintosh laryngoscope for patients requiring intubation when manual inline neck stabilization was applied.

Keywords: C-MAC® laryngoscope, Macintosh laryngoscope, intubation, neck immobilization, manual inline stabilization.

Introduction

Securing the airway with tracheal intubation in a patient suspected or known to have a cervical spine injury has always been a challenge regardless of whether it is conducted in a controlled operating room environment, in a busy critical zone of the emergency department or in an out-of-hospital setting. This has been recognized since the early 1950’s and by the early 1980’s the standard of care to overcome this scenario was to use the time tested formulae of direct laryngoscopy with tracheal intubation using manual inline stabilization (MILS) with a Macintosh laryngoscope. MILS is a maneuver that ensures a neutral alignment and motionless cervical spine

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during the intubation process and is carried out by a healthcare personnel who places a hand on each side of the patient's neck with fingers pressed on each mastoid process and the hands then pressed firmly into the operating table. While the practice of MILS was considered to be the standard care with regards to prevention or worsening of any neurological morbidity, it has been found that MILS produced significantly worse laryngoscopy view upon direct laryngoscopy for tracheal intubation. The delay in or a failed tracheal intubation could potentially result in hypoxia leading to worse outcomes and is a leading cause of morbidity and mortality for patients in both the operative setting and in an emergency situation.

With due consideration to the above, advances in technology have provided alternatives to the conventional Macintosh laryngoscope to perform direct laryngoscopy during a MILS scenario. Considerable development has occurred especially in the field of indirect laryngoscopy using video-assisted techniques producing devices such as the Glidescope® (Saturn Biomedical System Inc., Burnaby, Canada) and the Airwayscope® laryngoscope (Pentax Corporation, Tokyo, Japan). These new devices have been shown to have definite advantages over the conventional Macintosh direct laryngoscopy in scenarios where MILS was applied. These included better glottic visualization, less optimizing maneuvers needed for a successful intubation and more favorable hemodynamic profiles during the intubation itself.

The C-MAC® (Karl Storz, Tuttingen, Germany), a portable video-laryngoscope is unique as it offers an original Macintosh blade shape with an approximately 80° angle of view and practically eliminated fogging of the camera. Owing to its similar design to the Macintosh blade, there would not be very much of a learning curve to using it by most anesthetic doctors. An initial study showed great promises in it being able to obtain good view of the glottis on the first attempt in all patients. At this point of time the question of whether any video-laryngoscope is definitely better in MILS is yet to be answered convincingly.

The aim of this study was to compare laryngoscopic views (based on Cormack and Lehane grading) during tracheal intubation when using either the C-MAC® video-laryngoscope or the Macintosh laryngoscope during MILS. The time taken to intubate (seconds), number of intubation attempts, optimization maneuvers required, complications encountered and the changes in hemodynamic parameters of the patients being intubated were also compared.

Methods

This study design was based on a prospective, randomised, single-blind clinical trial that was done following approval of the Dissertation Committee of the Department of Anesthesiology and Intensive Care, Universiti Kebangsaan Malaysia Medical Center (UKMMC) and the Research Ethics Committee of UKMMC (Research No. FF-024-2011). After obtaining written informed consent, ninety patients between 18 and 60 years of age with American Society of Anesthesiology (ASA) physical status I or II, scheduled for elective surgery under general anesthesia that required tracheal intubation were enrolled in the study. Those patients who had features of difficult airway (e.g. Mallampati grade >III, thyromental distance <6cm or a Body Mass Index >35kg/m²), pregnant or had other conditions associated with an increased risk of pulmonary aspiration were excluded from the study. Likewise patients who had pre-existing cervical neck pathologies, hypertensive individuals and those with allergies or contraindications to medications used for general anesthesia were excluded as well.

The selected patients were then randomised into two arms. Group 1 patients were intubated with the C-MAC® video-laryngoscope whereas patients in Group 2 were intubated with the Macintosh (MAC) laryngoscope. This randomisation process was done using ‘Random Numbers Tables’ that were computer generated.

In the operating room, all patients received a standardized general anesthetic. Both groups of patients were started on IV fluid of Lactated Ringer’s solution. Induction of anesthesia with the administration of 100% oxygen at 6 liters/min, IV fentanyl (2 mcg/kg) and IV propofol (up to 2 mg/kg) was carried out to induce unconsciousness defined as loss of eyelash reflex. Subsequently manual
ventilation was initiated with sevoflurane (2.0%) in oxygen as test ventilation, before administration of IV rocuronium (0.6 mg/kg) as a muscle relaxant. Standard anesthetic monitoring which included ECG, non-invasive blood pressure (NIBP), oxygen saturation (SpO₂), end tidal carbon dioxide (EtCO₂) and a multigas analyzer were provided to both groups of patients. After full muscle relaxation was confirmed with a nerve stimulator, the patient’s neck was immobilized utilizing MILS technique. The MILS was performed by another medical officer who stood at the right side of the patient caudal to the intubator and the patient’s airway. The assistant placed a hand on each side of the patient’s neck with fingers pressed on each mastoid process and the hands were then pressed firmly into the operating table ensuring neutral alignment and a motionless cervical spine as described in Advanced Trauma Life Support.

Intubation was then performed with one of the two devices (both with blade #3) as per the group that the patient was in. A tracheal tube size #7.5 - 8 for males and #7 - 7.5 for females was used. Once the vocal cords were visualized they were graded using the Cormack and Lehane (CL) grading. After successful tracheal intubation in all patients, mechanical ventilation was commenced for the duration of the procedure with anesthesia being maintained with sevoflurane (1.0 MAC) and air-oxygen mixture (FiO₂ 0.5).

In each group, tracheal intubation was considered a failure if it could not be established with three attempts, within three minutes or desaturation of SpO₂ <92%. In the event of such an incident, MILS was abandoned and intubation was performed using the Macintosh blade with optimal patient head and neck positioning. Any additional instruments to aid intubation were used if deemed necessary. All intubations were performed by the investigator SH, an anesthetic trainee whose previous experience includes >30 intubations with the C-MAC® and more than 5 years frequent use of the Macintosh laryngoscope.

Data collected included CL score, time to intubate in seconds (defined as when either of the blades was inserted beyond the lip until first appearance of the capnograph waveform) and number of intubation attempts. In addition, the nature of optimisation maneuvers done such as the use of a gum elastic bougie (GEB), external laryngeal manipulation (ELM) or presence of a second assistant were also recorded. Complications including fogging of lens, local trauma (mucosal/lip/dental), hypoxia (SpO₂ <92%) and failed intubation were recorded. Recording of the patient’s baseline mean arterial pressure (MAP) and heart rate (HR) along with repeat recordings at fixed one minute time intervals for 5 minutes were done. No other medications were administered, or procedures performed during the 5-minute data collection period after tracheal intubation. Subsequent management was left to the discretion of the anesthetist providing care for the patient.

The sample size was obtained using the computer software: “Power and Sample Size Calculations Version 3.0.14, January 2009” otherwise known as PS2. (http://bisotat.mc.vanderbilt.edu/powersamplesize). The alpha error was set at 5% (p<0.05) and a beta error of 20% (power = 0.8). The p0 was set at 0.2 from a previous study with the macintosh laryngoscope using MILS where 20% of patients obtained CL grade 1 views9. Since the C-MAC® video-laryngoscope has not been studied previously in this manner, the probability of obtaining a CL grade 1 view was estimated as 50% from a preliminary study12. Thus the p1 was set at 0.5 and the results calculated using the sample size software as discussed previously. The sample size required was found to be 38 patients, which was rounded up to 40 patients on each arm. A dropout rate of 10% was factored in to give a sample size of 45 patients in each arm and thus a total sample size of 90 patients.

Data analysis was done using Chi-square test for non-parametric data and Student’s t-test for parametric data. A p value of less than 0.05 was considered as statistically significant. All analysis was performed using SPSS for Windows (version 12.0, Chicago, IL).

Results

A total of 90 patients were enrolled into the study with 45 patients in each group. There were no significant differences in the patient characteristics such as age, gender, ASA physical status, BMI and Mallampati grades between the two groups as shown in Table 1.
The CL grade was significantly better in Group 1 using the C-MAC® producing a CL Grade I for 67% of the study population compared to Group 2 with only 38% of the sample having CL Grade I as shown in FIGURE 1 (p <0.05). None of the patients in Group 1 had CL Grade IV whereas there was one patient in Group 2 with CL grading of IV. The majority of patients intubated with the MAC (56%) were found to have a CL Grade of II. The CL grading correlated well with the time to intubate (TTI) which was found to be significantly shorter in Group 1 with a mean time of 32.7 ± 6.8 vs. 38.8 ± 8.9 seconds for Group 2 (p = 0.001) as shown in Table 2.

The number of intubation attempts required in the two groups however was found to be not significantly different. The majority of patients in both

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**Table 1**

*Demographic and patient characteristics. Values expressed as Mean ± SD or number (%)*

<table>
<thead>
<tr>
<th></th>
<th>C-MAC® (n=45)</th>
<th>MAC (n=45)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>40.8 ± 15.1</td>
<td>41.6 ± 14.8</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>22 (48.9)</td>
<td>24 (53.3)</td>
</tr>
<tr>
<td>Male</td>
<td>23 (51.1)</td>
<td>21 (46.7)</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>26.2 ± 4.7</td>
<td>26.9 ± 3.7</td>
</tr>
<tr>
<td>ASA I</td>
<td>30 (66.7)</td>
<td>32 (71.1)</td>
</tr>
<tr>
<td>Mallampati I</td>
<td>25 (55.6)</td>
<td>22 (48.9)</td>
</tr>
<tr>
<td>Mallampati II</td>
<td>20 (44.4)</td>
<td>23 (51.1)</td>
</tr>
</tbody>
</table>

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**Table 2**

*Intubation characteristics. Values are expressed as Mean ± SD or numbers (%)*

<table>
<thead>
<tr>
<th></th>
<th>C-MAC® (n=45)</th>
<th>MAC (n=45)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TTI (seconds)</td>
<td>32.7 ± 6.8*</td>
<td>38.8 ± 8.9</td>
</tr>
<tr>
<td>Intubation attempts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>44 (97.8)</td>
<td>39 (86.7)</td>
</tr>
<tr>
<td>2</td>
<td>1 (2.2)</td>
<td>4 (8.9)</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>2 (4.4)</td>
</tr>
<tr>
<td>Optimization maneuvers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>38 (84.4)**</td>
<td>27 (60.0)</td>
</tr>
<tr>
<td>GEB</td>
<td>3 (6.7)</td>
<td>1 (2.2)</td>
</tr>
<tr>
<td>ELM</td>
<td>3 (6.7)</td>
<td>14 (31.1)</td>
</tr>
<tr>
<td>ELM + GEB</td>
<td>1 (2.2)</td>
<td>3 (6.7)</td>
</tr>
<tr>
<td>Failed intubation</td>
<td>0</td>
<td>2 (4.4)</td>
</tr>
<tr>
<td>Lip trauma</td>
<td>0</td>
<td>1 (2.2)</td>
</tr>
<tr>
<td>Esophageal intubation</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Dental trauma</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>SpO₂&lt;92%</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

* p = 0.01, ** p <0.05.

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**Fig. 1**

*Cormack and Lehane grades obtained in the two groups*
groups were able to be intubated in the first attempt. Optimisation maneuvers were found to be commonly required for patients in Group 2 with 31% of them requiring ELM and 7% required both ELM and GEB. In contrast 84% of Group 1 patients required no such measures for successful tracheal intubation and only 7% of patients needed the help of either a GEB or ELM ($p =0.01$).

There were no reported complications in patients from Group 1. In Group 2, there were two cases of failed intubation and one case of minor lip trauma. However on statistical analysis these results were not significant. Additionally, there was no occurrence of oxygen desaturation or esophageal intubation encountered on both the study arms. On a side note, we experienced fogging occurring in 11% of the cases on the C-MAC® arm but this was not severe enough to impair the performance of the device. This was likely due to the presence of a built in software system that initiates pre-warming of the optical system by the camera light.

Both groups had similar trends of MAP and HR over the 5-minute data collection period as shown in Figures 2 and 3. There were no recorded increases of more than 20% of their respective baseline values of these two parameters. However at one point of time (T +1: one minute post intubation) Group 2 had a higher MAP of 93.5 ± 16.0 vs. 86.9 ± 10.4 mmHg for Group 1($p<0.05$). The rest of the data points were not statistically different between the groups.

**Discussion**

From this study, we found that using the C-MAC® video-laryngoscope would be of benefit in patients with
MILS due to its superiority in various aspects compared to the Macintosh laryngoscope. The C-MAC® was able to obtain better CL scores with a majority of them being CL Grade I without requiring additional optimization maneuvers. The Macintosh laryngoscope on the other hand had majority of CL II grades. Poor laryngoscope views in the setting of MILS is a known factor that will complicate intubation in this group of patients. The limited neck movement from the MILS made direct laryngoscopy become more challenging mainly due to difficulties in aligning the oral, pharyngeal and laryngeal axis which was required for a successful tracheal intubation.

In order to overcome this situation, having an indirect laryngoscope such as the C-MAC® with a camera mounted on the blade capturing live images and projecting them onto a video screen dramatically reduces the line of sight required which in turn resulted in the much improved CL scores as seen occurring in our study. This advantage was also noted by McElwain and Laffey where 35% of patients intubated with the C-MAC® had a CL Grade 1 vs. the Macintosh which produced CL Grade 1 in 19% of their study sample.

The mean difference of 18 seconds reduction in TTI for the C-MAC® obtained in our study may initially seem unremarkable at its face value especially since the lengthened period of apnea for the Macintosh group was not associated with desaturation or other hemodynamic changes. However, in an emergency airway management situation where the patient is at risk of hypoxia, any reduction in the TTI could be a very crucial factor. In a similar study the TTI recorded however was longer although insignificantly for the C-MAC® [TTI of 27secs IQR 18, 47] vs. Macintosh [TTI of 23 sec IQR 14, 47]. A point to note in that study was that the measurement of TTI was not standardized. The investigators measured the TTI from the time the laryngoscope blade passed the lips up till they visualized the ETT passing the vocal cords and in cases where the ETT was not visualized, the appearance of capnograph tracing was taken as the end point. In our study the TTI was standardized and recorded for all intubations from the time the laryngoscope blade passed the lips till the appearance of the capnograph.

Using the C-MAC® also resulted in less need for additional optimization maneuvers compared to the Macintosh Group. In our study we found that the Macintosh group required the use of ELM in 61% of patients which was similarly seen in other studies as well. The main reason behind this was because of the need for the intubator to obtain a best line of sight by aligning the intubation axis as has been discussed earlier. This however is not needed when using the C-MAC® as the vocal cords are readily visualized due to the blade mounted camera and 80° angle of view.

During the course of our intubations, we did not require a change in blade size or use of second assistant for either of the groups and blade size #3 was used for both devices.

Patients from both groups had no significant complications. Oxygenation was well maintained despite the variation in intubation times due to the process of preoxygenation that was conducted in our study. There may possibly have been hypoxemia if this crucial step was omitted highlighting once again its importance especially in emergency airway management. The lack of significant airway trauma in both groups as observed in our study arise possibly because of the similar shape and structure of the two laryngoscope blades that results in similar mechanical forces and movements during intubation when using either of the devices. These similarities in the low occurrence of airway trauma was also observed in other studies as well.

There are a few limitations that can be identified in our study. Firstly, it is not possible to blind the investigator about the device being used. The performance of the device is highly dependent on the capabilities of the operator. However due to the overall similar design of the two blades this would be quite unlikely to affect performance markedly. Nevertheless all the intubations were carried out by a single investigator (SH) so that the variability in technique and operator bias could be minimized. The other issue lies with the subjectivity of the CL scoring. Once again by utilizing a single operator we hope that this can be overcome as well.

One important factor to keep in mind is that this study was conducted on adequately fasted, pre-oxygenated patients with no difficult airway
management anticipated. These patients underwent elective surgery exclusively. Thus the situation would be expected to be very different in the post-trauma patients presenting to the emergency department or operating room for emergency airway management. Further well planned studies will be required to assess how the C-MAC® performs in these situations.

Conclusion

In conclusion, our study demonstrated that the C-MAC® video-laryngoscope was superior for patients being intubated during manual inline neck stabilization when compared to the standard Macintosh laryngoscope.
References

The key to Lock-up Postoperative Pain

STEP I
Initial bolus
Inject 1 ampoule Tramal® 100 mg I.V. or I.M. slowly over 2-3 minutes

Ways of administration after initial bolus

STEP II
Infusion
Inject 2 ampoules Tramal®, each 100 mg, in 500ml of infusion solution. Infusion rate 12-24 mg Tramal® (16-20 drops/min or 30-60 drops/min).

PCA
Subsequent increments of 26 mg with a lock-out time of 5 minutes.

Injection
Usual dose is 10 mg or 100 mg 4-6 hourly up to a total daily dose of 400 mg except in special clinical circumstances where intravenous daily dose can be up to 400 mg. Further treatment with Tramal® boluses on demand.

If needed further doses of Tramal® 50 mg up to a total of 200 mg (including the initial bolus) within the first 60 min.

STEP III
Follow-up

- 1-2 capsules every 4-6 hours
- 50 mg
- 20-40 drops every 4-6 hours
- 100 mg
- 1 suppository every 4-6 hours
- slow release 100 mg, 150 mg, 200 mg 1 tablet every 12 hours

Intra-Operative

Loading Dose
2.5 - 3 mg/kg I.V. at wound closure

Post-Anaesthesia Care Unit

If intra-operative dose not given then:

BOLUS I.V.*
100 mg over 2-3 mins

An intra-operative loading dose of Tramal® will reduce PONV rates

*If needed further doses of 50 mg up to a total of 200 mg (incl. the initial bolus) may be given within the first 60 min.

References:
For patients with localized
BURNING
SHOOTING
STABBING
Neuropathic pain
WORKS WHERE IT HURTS
BRIDION—optimal neuromuscular blockade management and improved recovery

Predictable and complete reversal

- 98% of BRIDION patients recovered to a TOF\(^+\) ratio of 0.9 from reappearance of T\(_2\) \(^+\) within 5 minutes\(^2\)
- 97% of BRIDION patients recovered to a TOF\(^+\) ratio of 0.9 from 1 to 2 PTCs \(^1\) within 5 minutes\(^3\)

Rapid reversal

- BRIDION rapidly reversed patients from reappearance of T\(_2\) \(^+\) in 1.4 minutes\(^2\)
- BRIDION rapidly reversed patients from 1 to 2 PTCs \(^1\) in 2.7 minutes\(^3\)

BRIDION is indicated for the reversal of neuromuscular blockade induced by rocuronium or vecuronium. In children and adolescents (aged 2-17 years), BRIDION is only recommended for routine reversal of moderate rocuronium-induced neuromuscular blockade.\(^1\)

Important safety information

BRIDION is not recommended in patients with severe renal impairment. Studies in patients with hepatic impairment have not been conducted and, therefore, patients with severe hepatic impairment should be treated with great caution. Caution should be exercised when administering BRIDION to pregnant women as no clinical data on exposed pregnancies are available.

BRIDION has not been investigated in patients receiving rocuronium or vecuronium in the Intensive Care Unit (ICU) setting. If neuromuscular blockade is required within 24 hours of BRIDION administration, a non-reversal neuromuscular blocking agent should be used instead of rocuronium or vecuronium. The most commonly reported adverse reactions were dysgeusia (metal or bitter taste) and anesthetic complications (movement, coughing, grimacing, or sucking on the endotracheal tube). In patients treated with BRIDION, a few cases of awareness were reported. The relation to BRIDION was uncertain. In a few individuals, allergic-like reactions (ie, flushing, erythematous rash) following BRIDION were reported. Clinicians should be prepared for the possibility of allergic reactions and take the necessary precautions. In a trial of patients with a history of pulmonary complications, bronchospasm was reported in 2 patients and a casual relationship could not be fully excluded.

Volunteer studies have demonstrated a slight (17%-22%) and transient (<30 minutes) prolongation of the prothrombin time/activated partial thromboplastin time (PT/aPTT) with BRIDION; however, clinical studies have demonstrated no clinically relevant effect on peri- or postoperative bleeding complications with BRIDION alone or in combination with anticoagulants. As BRIDION has demonstrated an in vitro pharmacodynamic interaction with anticoagulants, caution should be exercised. In patients on anticoagulation for a pre-existing or comorbid condition. This pharmacodynamic interaction is not clinically relevant for patients receiving routine postoperative prophylactic anticoagulation. Although formal interaction studies have not been conducted, no drug interactions were observed in clinical trials. Preclinical data suggest that clinically significant drug interactions are unlikely with the possible exceptions of toremifene, fusidic acid, and hormonal contraceptives.

\(^1\) Train-of-four
\(^2\) Post-tetanic count
\(^3\) Second twitch


Please see summary of product characteristics for full prescribing information.

MSD
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Guided Nerve Blocks

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Blocks Under Ultrasonic Monitoring