Randomized controlled trial comparing the McGrath videolaryngoscope with the C-MAC videolaryngoscope in intubating adult patients with potential difficult airways

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Editor’s key points
- The McGrath videolaryngoscope was compared with the C-MAC videolaryngoscope in patients with anticipated difficult airway.
- The C-MAC videolaryngoscope allowed a quicker and easier tracheal intubation.
- This research adds important data to ongoing comparisons between various newer airway devices.

Background. Difficult and failed intubations, although rarely encountered, are major causes of morbidity and mortality in the current anaesthetic practice. To reduce the incidence of difficult and failed intubations, several devices including the recently developed videolaryngoscopes are available. This randomized controlled study aims to compare the use of the McGrath videolaryngoscope with the C-MAC videolaryngoscope in adult patients with potential difficult airways.

Methods. A total of 130 patients with the Mallampati grade of ≥3, requiring orotracheal intubation, were randomized to either having intubation with the McGrath videolaryngoscope or the C-MAC videolaryngoscope. The primary outcome was time to intubation. The laryngoscopic view, the number of intubation attempts, the proportion of intubation success, the ease of intubation, the haemodynamic responses to intubation, and the incidence of any complications were also recorded.

Results. Time to successful intubation with the C-MAC videolaryngoscope was shorter when compared with the McGrath videolaryngoscope (50 s [inter-quartile range (IQR) 38–70] vs 67 s (IQR 49–108), P<0.001), despite the McGrath videolaryngoscope providing significantly more grade 1 laryngoscopic views. The C-MAC videolaryngoscope also resulted in significantly fewer intubation attempts and greater ease of intubation when compared with the McGrath videolaryngoscope. There were no statistically significant differences in the proportion of intubation success, the number of complications, and the changes in haemodynamic responses between the two videolaryngoscopes.

Conclusions. The C-MAC videolaryngoscope allowed a quicker intubation time, fewer intubation attempts, and greater ease of intubation compared with the McGrath videolaryngoscope when used in patients with the Mallampati grade of ≥3.

Keywords: airways; anaesthetic techniques; equipment; laryngoscopes; tracheal intubation; videolaryngoscopes

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meta-analysis have shown that videolaryngoscopes can offer better views of the glottis when compared with standard direct laryngoscopy and are alternative options for the management of difficult airways.\textsuperscript{9–11} However, there have been limited studies comparing different types of videolaryngoscopes. The majority of the studies available were manikin studies.\textsuperscript{12–16} There is currently a paucity of clinical research comparing different types of videolaryngoscopes, particularly when used in patients with potential difficult airways.

The objective of this study is to compare the McGrath Series 5 videolaryngoscope with the C-MAC videolaryngoscope in intubating adult patients with potentially difficult airways. The McGrath Series 5 videolaryngoscope is a portable, lightweight unit with a disposable angulated acrylic blade.\textsuperscript{7} It requires a pre-curved stiletted tracheal tube and insertion along the midline of the oral cavity. The C-MAC videolaryngoscope on the other hand has the same shaped blade as a standard Macintosh blade.\textsuperscript{4} It is inserted in the oral cavity using the standard direct laryngoscopic technique. We hypothesize that the C-MAC videolaryngoscope would allow a faster tracheal intubation time compared with the McGrath videolaryngoscope in adult patients with the Mallampati grade of $\geq 3$.

**Methods**

After obtaining approval from the Melbourne Health Human Research Ethics Committee and registration from the Australian New Zealand Clinical Trials Registry (registration number: ACTRN12610000778088), 130 adult patients undergoing elective surgery requiring orotracheal intubation at the Royal Melbourne Hospital were recruited. We included patients if they were $\geq 18$ yr of age, ASA I–III, and had a modified Mallampati score of 3 or 4.\textsuperscript{17} We assessed the modified Mallampati score by one observer (A.L.H.) with patients sitting upright, the head in the neutral position, and requested patients to open their mouth maximally and protrude the tongue without phonation (class 3: soft and hard palate and base of the uvula were visible, class 4: soft palate not visible at all—only hard palate visible).\textsuperscript{18 19}

Exclusion criteria included non-English speaking patients; presence of any other predictors of difficult intubation, including decreased inter-incisor distance ($< 3$ cm), short thyromental distance ($< 6$ cm), and reduced neck extension ($< 80^\circ$ from neck flexion); cervical spine instability; or risk of pulmonary aspiration.

After obtaining written informed consent, each patient was randomly allocated to either the McGrath videolaryngoscope or the C-MAC videolaryngoscope study group. This was done by a closed envelope technique using a computer-generated block randomization method in blocks of 10. The principal investigator performed the computer randomization and put the allocation result in individual numbered and sealed envelopes before the commencement of the study. The person responsible for recruitment was unaware of the allocation result. The allocation was revealed only after the patient was consented for the study.

Patients’ baseline characteristic data were collected before operation. Each patient was pre-oxygenated with 100% O$_2$ until end-tidal O$_2$ reached $\geq 70\%$. Thereafter, anaesthesia was induced using the drugs of the treating anaesthetist’s choice. The lungs were then ventilated with 100% O$_2$ using a bag and a mask, and laryngoscopy was attempted once a train of four of zero was achieved. Depending on the randomization, laryngoscopy was performed with either the McGrath videolaryngoscope or the C-MAC videolaryngoscope (blade size 3 or 4) by an anaesthetist with a minimum of 10 yr experience and who had used both devices at least 10 times clinically. At the Royal Melbourne Hospital, both the McGrath and the C-MAC videolaryngoscopes had been available for over a year before the commencement of the study. Therefore, all of the anaesthetists who participated in this study were very familiar with using either of these devices. Both devices were used according to the manufacturers’ recommendations.\textsuperscript{4 20–22} A standard Mallinckrodt\textsuperscript{8} oral tracheal tube was used (size 7 or 7.5 for females and size 8 or 8.5 for males).

The primary outcome variable was time taken for successful intubation, defined as time from when the allocated videolaryngoscope was inserted into the participant’s mouth until end-tidal CO$_2$ was detected. If more than one intubation attempt was needed, the anaesthetized patient received bag-and-mask ventilation between attempts and various manoeuvres could be used, including external laryngeal pressure and use of a bougie. An intubation attempt was counted each time the anaesthetist attempted to pass a tracheal tube through the vocal cord. Failed intubation was defined as failure after three attempts with the allocated videolaryngoscope, and an alternative airway management plan would be instituted by the treating anaesthetist. If intubation with the allocated videolaryngoscope failed, then intubation time was measured until the final attempt had failed and a decision on alternative airway management was declared.

Secondary outcomes were the best grade of view on the screen of the videolaryngoscope at laryngoscopy according to the Cormack and Lehane nomenclature,\textsuperscript{23} the number of attempts required for successful intubation, the proportion of successful and unsuccessful intubations with each videolaryngoscope group, the ease of intubation which was graded by the intubating anaesthetist on a numerical rating scale (NRS, where 0 was the most difficult and 10 the easiest), and the haemodynamic changes during intubation. Any associated complications, such as hypoxia ($\text{SpO}_2 < 90\%$), and oropharyngeal or dental injuries in relation to the tracheal intubation, were also reported to the observer by the intubating anaesthetist.

**Statistical analysis**

Based on previous studies,\textsuperscript{24 25} we determined that the mean intubation time for the McGrath videolaryngoscope was 51.3 s with a standard deviation of 31.8 s. Power analysis showed that in order to show 50% effect size, with 80%
power at the 0.05 level of significance, 64 patients were required for each group. Therefore, we recruited 130 patients in total to account for possible drop-outs.

The Mann–Whitney U-test was used to analyse the time for successful intubation and the ease of intubation in view of the marked skewness and kurtosis of the data. The Fisher exact test was used to analyse the Cormack and Lehane view at laryngoscopy, the number of intubation attempts, the number of successful and failed intubations, and the incidence of complications. For the analysis of haemodynamic response to intubation, a repeated-measures analysis of variance was used. Statistical analysis was performed using Systat V7 (1997, SPSS Inc.).

**Results**

The baseline characteristics of the patients were similar in both groups, as shown in Table 1. The median time taken to perform successful intubation was significantly longer in the McGrath group when compared with the C-MAC group (median 67 vs 50 s; Fig. 1). Although the McGrath videolaryngoscope provided more grade 1 laryngoscopic views than the C-MAC videolaryngoscope, it significantly required more than one attempt in order to achieve successful intubation (Table 2).

Using the McGrath videolaryngoscope resulted in five failed intubations, whereas the C-MAC videolaryngoscope resulted in one failed intubation. This difference was not statistically significant (Table 2). The C-MAC videolaryngoscope was consistently rated by anaesthetists as an easier device to use when compared with the McGrath videolaryngoscope, and this difference on the NRS was statistically significant (median 6 vs 9; Table 2). There were in total seven minor oropharyngeal mucosal injuries as a result of the intubation, six from using the McGrath videolaryngoscope and one from the C-MAC videolaryngoscope. None of the patients required further management.

In both groups, patients showed significant changes in heart rate and arterial pressure from baseline to post-intubation. However, there was no statistical significant difference in the changes between the two groups (Table 2).

**Discussion**

Although many studies have shown that videolaryngoscopes could provide better views of the glottis when compared with conventional direct laryngoscopy, this was the first study comparing the McGrath videolaryngoscope with the C-MAC videolaryngoscope in patients with one clinical marker of a potentially difficult airway. In this study, we showed that

![Fig 1 Comparison of time to intubation (s) between the McGrath group and the C-MAC group. Values are in median, inter-quartile range, maximum and minimum. *Statistically significant, P<0.001.](image)

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Comparison of patients' baseline characteristics between the McGrath and C-MAC groups. Values are mean (so) (95% confidence interval) or number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline characteristics</td>
<td>McGrath group (n=65)</td>
</tr>
<tr>
<td><strong>BMI (kg m⁻²)</strong></td>
<td>29.4 (5.5) (28.0 – 30.7)</td>
</tr>
<tr>
<td><strong>ASA</strong></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>3</td>
</tr>
<tr>
<td>II</td>
<td>23</td>
</tr>
<tr>
<td>III</td>
<td>39</td>
</tr>
<tr>
<td><strong>Mallampati class</strong></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>62</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Table 2</th>
<th>Comparison of the laryngoscopic view, the number of intubation attempts, the proportion of successful to failed intubation, the ease of intubation, complications and haemodynamic changes between the McGrath and C-MAC groups. Values are median (inter-quartile range) or number, except for haemodynamic change from baseline, which is expressed as mean (so)</th>
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<tbody>
<tr>
<td>Outcomes</td>
<td>McGrath group (n=65)</td>
</tr>
<tr>
<td><strong>Laryngoscopic view</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>60</td>
</tr>
<tr>
<td>≥2</td>
<td>5</td>
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<tr>
<td><strong>Number of intubation attempts</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>45</td>
</tr>
<tr>
<td>&gt;1</td>
<td>20</td>
</tr>
<tr>
<td><strong>Proportion of successful to failed intubations</strong></td>
<td>60.5</td>
</tr>
<tr>
<td><strong>Ease of intubation 1 (difficult) –10 (easy)</strong></td>
<td>6 (5–8)</td>
</tr>
<tr>
<td><strong>Any complications</strong></td>
<td>6</td>
</tr>
<tr>
<td><strong>Haemodynamic change from baseline</strong></td>
<td></td>
</tr>
<tr>
<td>Heart rate (%)</td>
<td>21.7 (0.2)</td>
</tr>
<tr>
<td>Systolic arterial pressure (%)</td>
<td>2.5 (0.2)</td>
</tr>
</tbody>
</table>
the McGrath videolaryngoscope provided significantly more grade 1 laryngoscopic views than the C-MAC videolaryngoscope in patients with poor Mallampati scores. However, the McGrath required much longer intubation time and more attempts before successful intubation could be achieved. The C-MAC videolaryngoscope was regarded by most anaesthetists as a much easier device to use when compared with the McGrath videolaryngoscope. There was, however, no significant difference in the proportion of successful intubation, the number of complications, and the haemodynamic changes between the two groups.

The difference of 17 s in the time of intubation between the two laryngoscopes is consistent with the result found in one previous study, which compared the earlier model of the C-MAC videolaryngoscope, the V-MAC videolaryngoscope with the McGrath videolaryngoscope in morbidly obese patients.26 This difference may reflect the fact that the McGrath videolaryngoscope blade has a more significant anterior bend and hence requires a modified intubation technique when compared with the standard Macintosh blade design of the C-MAC videolaryngoscope. The McGrath videolaryngoscope requires a styletted tracheal tube and the time taken to remove the stylet could be an additional factor for the slower average time to intubation. Although the use of end-tidal CO2 as the endpoint for time to intubate may have disadvantaged the McGrath videolaryngoscope in this study, it is the most clinically relevant measure as it reflects the time when the patient is without ventilation.

Although the McGrath videolaryngoscope provided significantly more grade 1 laryngeal views than the C-MAC videolaryngoscope, it required more intubation attempts. This is in line with existing studies which suggest that the McGrath videolaryngoscope consistently provides optimal laryngeal inlet views in manikins with simulated difficult airways and patients with difficult airways.20 28 However, a good laryngeal view does not necessarily translate to easy intubation.15 28

Interestingly, all of the five failed intubations in the McGrath group had grade 1 views at videolaryngoscopy; yet, the anaesthetists were not able to pass the tracheal tube through the vocal cords. They were subsequently successfully intubated with a Macintosh laryngoscope with three of these intubations requiring the aid of a bougie. This might support the findings of a previous study that the McGrath videolaryngoscope may prolong the intubation time of patients with uncomplicated airways.29 The C-MAC videolaryngoscope resulted in one failed intubation where a grade 2 view was obtained at laryngoscopy. However, the large epiglottis was obscuring the vocal cords and the anaesthetist was unable to pass the tracheal tube or a bougie behind the epiglottis. The McGrath videolaryngoscope was chosen by the intubating anaesthetist as the alternative airway device and this resulted in a grade 1 view with an easy pass of the bougie. This highlighted the fact that in some patients, it might be beneficial to use a videolaryngoscope with a sharp anterior bend on the blade design.

Both devices had been available in the department for over a year before the commencement of the study. Most anaesthetists were familiar and competent in the use of both devices. However, the C-MAC videolaryngoscope was consistently rated by anaesthetists as an easier device to use than the McGrath videolaryngoscope. This is in agreement with the tightly clustered inter-quartile range for the time to intubation in the C-MAC group. This may reflect clinicians’ familiarity with the shape of the blade as the C-MAC matches the shape and the curve of the Macintosh and can be used with the same technique. The McGrath videolaryngoscope could potentially be made easier to use if there is a stylet or bougie available, of which the distal tip could be freely manoeuvred to couple the exaggerated curve of the McGrath blade. In conventional laryngoscopy, the Cormack and Lehane view correlates well with overall intubation difficulty.23 30 This was not replicated in our study. In this study, we found that the time to intubate and the number of intubation attempts were more closely related to the ease of intubation than the laryngoscopic view. Therefore, it is important to have a composite of outcomes in studies involving videolaryngoscopes.

There are a few limitations to this study. First, we were not able to blind the intubating anaesthetists or the independent observer from the randomization of the videolaryngoscope. This could have led to bias if the anaesthetist already had a preference towards one device. However, the primary outcome, time to intubation, and most of the secondary outcomes were well defined and objective. Secondly, we chose the Mallampati score as the only predictor of difficult airway. A previous study has shown that 2.1% of patients with the Mallampati grade of ≥ 3 would fall into Cormack and Lehane grade 3 or 4 under videolaryngoscopy.31 We understand that this may limit the clinical application of our findings from this study. However, we believed that this test was one of the most routinely performed preoperative airway assessment test among anaesthetists. It was feasible and clinically relevant.

To conclude, the C-MAC videolaryngoscope allows a significantly faster intubation time, fewer intubation attempts, and is considered an easier device to use in patients with poor Mallampati scores when compared with the McGrath videolaryngoscope. On the other hand, the McGrath videolaryngoscope provides more grade 1 laryngeal views, possibly due to the exaggerated angulation of the blade. Videolaryngoscopes in general may offer promise for intubation of the difficult airway.3–11 Further studies to compare different videolaryngoscope blade designs used in patients with different types of airway problems will be useful to assist anaesthetists in selecting the most appropriate device in each individual clinical scenario.

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Declaration of interest
None declared.

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