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Ease of Intubation with the *McGRATH*® MAC, C-MAC® or Macintosh Laryngoscopes by Novice Operators in Simulated Difficult Airways – A Manikin Study

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Authors' contributions

This work was carried out in collaboration between all authors. Authors BHT, SML and AYT designed the study and did the literature searches. All authors were involved in writing the protocol and performing the study. Authors WWT, LQL and AYT analyzed the results and wrote the first draft of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

A variety of video laryngoscopes have been introduced to facilitate endotracheal intubations as failed intubations can result in morbidity and mortality. We aimed to compare the use of the conventional Macintosh laryngoscope, McGRATH® MAC and C- MAC® video laryngoscopes among novice operators. 37 medical students were recruited to perform oro-tracheal intubations in a human patient stimulator with simulated 'difficult airway' scenario using 3 devices: The Macintosh laryngoscope, McGRATH® MAC and C- MAC® video laryngoscopes. The success rate of tracheal intubation using the C-MAC® video laryngoscope (84%) was higher than both the McGRATH® MAC (59%) and the Macintosh laryngoscope (57%) (p=0.005). The use of video laryngoscopes were associated with lower incidence of oesophageal intubation (p<0.001)

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and deemed easier to use (p<0.001). Overall, the C-MAC® yielded a higher rate of successful tracheal intubation, a shorter time to glottic visualisation and was deemed to provide the greatest ease of intubation with novice practitioners.

Keywords: McGRATH® MAC; C- MAC®; video laryngoscopes; ease of intubation.

1. INTRODUCTION

In recent years, various video laryngoscopic devices, including the C-MAC®, have gained popularity as they are shown to be superior in the management of difficult airway scenarios because they allow improved view of the glottis opening without the need to align the oral, pharyngeal and laryngeal axes as compared to the conventional Macintosh laryngoscope [1-8]. These devices are especially useful in emergency situations, in particular outside the operating theatres when performed by staff who are less experienced in airway management or when proper patient positioning is suboptimal or difficult [9]. Multiple attempts with poor intubation technique can cause significant airway trauma, bleeding and oedema potentially leading to morbidity and mortality [10-12].

The McGRATH® MAC video laryngoscope (Aircraft Medical, Edinburgh, UK) and C-MAC® video laryngoscope (Karl Storz Endoscopy, Tuttlingen, Germany) both consist of laryngoscope blades with similar curvatures as that of the conventional Macintosh laryngoscope blade. Both incorporated a light source and miniature video camera positioned close to the tip of the laryngoscope blade. The design of the McGRATH® MAC video laryngoscope is compact and highly portable. It consists of a handle with a mounted 2.5 inch liquid crystal display (LCD) screen and a single-use acrylic disposable blade. The C-MAC® video laryngoscope consists of a laryngoscope that is attached via a cable to a separate larger 7 inch LCD screen, enabling extension of the viewing angle from a standard 15 degrees to 80 degrees [13,14]. With both video laryngoscopes, the larynx can be visualized either directly, or via the video display. Tracheal intubation can be achieved directly with the tracheal tube or with the aid of a malleable stylet or gum-elastic bougie.

The earlier McGRATH® Series 5 model video laryngoscope, was shown to provide good laryngeal views but required longer durations of intubation and a higher number of attempts before successful intubation was achieved, as compared to the CMAC® [15] video laryngoscope. This was attributed to the acute anterior angulation of the blade as compared to the C-MAC® video laryngoscope's blade which displaces soft tissues in a fashion similar to the conventional Macintosh laryngoscope blade, allowing room for tracheal tube insertion on the right. The McGRATH® MAC video laryngoscope was developed with a blade curvature similar to that of the C-MAC® [15] video laryngoscope. With additional advantages of portability, convenience and blade disposability, it could possibly be the device of choice for users who are less experienced in airway management. This is especially important in difficult airway situations outside the operating theatre where the physicians managing the airway are often novice operators before a skilled operator arrives on site. To date, we are not aware of any study that compares the use of Mc-GRATH® MAC, C-MAC® video laryngoscopes and the conventional Macintosh laryngoscope amongst novice operators. In this study, we aimed to compare the relative intubating efficacies of the Mc-GRATH® MAC, C-MAC® video laryngoscopes and the conventional Macintosh laryngoscope amongst novice operators who are fourth-year medical students in a simulated difficult airway using a high-fidelity human simulator.

2. METHODOLOGY

Following ethics committee approval from the Institutional Review Board (NHG DSRB Ref: 2012/00701), a pilot study involving fourteen fourth-year medical students, was performed over the months of June and July 2012. The participants were not compensated for their participation in the study in any way. Screening questionnaires were conducted to ensure that they had limited prior intubating experience (less than 5 previous attempts) using any of the conventional Macintosh laryngoscope, McGRATH® MAC and C-MAC® video laryngoscopes.

Teaching and demonstration of the usage of the three different airway devices for oro-tracheal intubation were shown through a 45 minutes session. However, the participants were not

allowed any practice with the devices. They then proceeded to attempt oro-tracheal intubation of the high-fidelity human patient stimulator (METI®) using each of the three different devices.

The orders in which the participants tried each device were randomised using a random number generator. All participants were allowed 3 minutes per attempt for each device to achieve tracheal intubation in a simulated METI 'difficult airway scenario' via the greatest degree of tongue inflation achieved by the computer programme. Should there be an oesophageal or failed intubation attempt, the timer continued during re-positioning and re-attempts at intubation up to 3 minutes. All tracheal intubations were performed with a #7.5 Portex® Poly Vinyl Chloride endotracheal tube with a stylet in-situ and pre-formed to a standardised curvature.

The primary outcome of successful tracheal intubation was studied. Successful oro-tracheal intubation was defined as the ability to achieve oro-tracheal intubation within 3 minutes. Based on the pilot study, the success rate of intubation using the McGRATH® MAC video laryngoscope and C-MAC® video laryngoscope was 80% compared to the Macintosh laryngoscope, which was 50%. Sample size of participants was calculated to be 30 using an alpha error of 5% and beta error of 80%, powered to detect a 10% difference in the rates of intubation between the groups based on baseline success rate of 50%.

The secondary outcomes were the rates of oesophageal intubation, time to achieve glottic visualization, time to tracheal intubation and perceived ease of intubation with each device.

Over the months of October 2012 to February 2013, we recruited 37 medical students to participate in the study. Participation was voluntary and informed consent was obtained. We excluded students who had any prior intubation experience.

Using the same methodology as the pilot study, the participants were allowed to perform oro-tracheal intubation using all three laryngoscopes with 3 minutes allowed per attempt. The time to successful tracheal intubation was recorded and defined as the time taken for the blade to advance past the teeth of the manikin to the time of connection of the tracheal tube with the 'self-inflating resuscitator' bag and successful inflation of the manikin's lungs. The time to achieve glottic visualization was the time taken for the blade to advance past the teeth of the manikin to the time of view of larynx.

Successful intubation was defined as an oro-tracheal intubation achieved within three minutes. Should there be an oesophageal intubation, the participants were allowed further attempts within the 3-minute time interval. Following placement of the tracheal tube, subjects were asked to grade the best view of the larynx achieved using each of the 3 devices by the Cormack and Lehane grading system. They also indicated their preferred device in terms of its ease of intubation using a 3-point scale (1 = easy, 2 = average, 3 = difficult).

3. RESULTS AND DISCUSSION

37 novice operators were successfully recruited with no dropouts. We analysed our data with SPSS Version 20.0 (SPSS Inc, Chicago IL, USA).

Success of intubation and oesophageal intubation rates were analysed using the Cochrans test. The time taken to visualisation was measured using one-way repeated measures of analysis of variance (ANOVA). Time to successful oro-tracheal intubation was measured using post-hoc 2 way comparison. Ease of intubation as ranked by the subjects was measured using the Friedmans test. The results are tabulated in Table 1.

The success rate of tracheal intubation using the C-MAC® video laryngoscope was 84% which was higher than both the McGRATH®MAC video laryngoscope (59%) and the conventional Macintosh laryngoscope (57%). The results showed a statistically significant decrease in the incidence of oesophageal intubation using both the McGRATH®MAC and C-MAC® video laryngoscopes as compared to the Macintosh laryngoscope. There was no statistically significant difference in the time to achieve intubation using any of these three devices. The C-MAC® video laryngoscope was deemed to be the easiest to use, followed by the McGRATH®MAC video laryngoscope and finally the conventional Macintosh laryngoscope.

In this simulated model of intubation in a difficult airway situation managed by novice operators, we have demonstrated that the use of the C-MAC® video laryngoscope yielded a higher rate of successful oro-tracheal intubation compared

Table 1. Success rate of oro-tracheal intubation and oesophageal intubation; time to glottis visualisation and intubation; ease of intubation using the three intubating devices. Results expressed as number (percentage), mean* ± standard deviation or median+ [interquartile range]

	Mc-GRATH® MAC (n=37)	C-MAC (n=37)	Macintosh (n=37)	p-value
Success of oro-tracheal intubation	22(59%)	31 (84%)	21 (57%)	0.005
Oesophageal intubation	1(3%)	0 (0%)	18 (49%)	<0.001
Time to glottic visualisation* (seconds)	32.7±26.6	19.5±17.3	49.0±43.4	0.022
Time to intubation* (seconds)	97.7±38.6	67.9±45.0	103.0±58.3	0.92
Ease of intubation+ (ranked on a 3-point number scale where 1 = easy, 2 = average, 3 = difficult)	2.0 [2-3]	1.0 [1-1.5]	3.0 [2-3]	<0.001

not only to the conventional Macintosh laryngoscope, but also to the McGRATH® MAC video laryngoscope. Fourth-year medical students were chosen to take part in this study because they will not be receiving any other formal airway management training after their anaesthesia training in fourth year. Upon graduation, they will proceed to become ward doctors and will be the first responders to patients in need of airway management.

The C-MAC® video laryngoscope resulted in significantly shorter time to glottic visualisation and was deemed to provide the greatest ease of intubation. Although similar curvatures exist between both blades of the video-laryngoscopes, the difference in the results could be due to the wider angle of view offered by the C-MAC® blade-mounted camera-lens and also the significantly larger video screen [16]. The design of the handle of C-MAC® video laryngoscopes is also different and provides greater ease of use.

Both the C-MAC® and McGRATH® MAC video laryngoscopes use were associated with significantly lower oesophageal intubation rates. This could potentially reduce morbidity due to aspiration of gastric contents secondary to gastric insufflation from unrecognised oesophageal intubation especially in emergency situations, outside the operating theatres when performed by users who are less experienced in airway management.

Although not statistically significant, the McGRATH® MAC trends toward a shorter time to glottic visualisation (32.7±26.6 seconds), as compared to the conventional Macintosh (49.0±43.4 seconds, p = 0.022). However, the time to intubation is relatively similar (97.7±38.6 seconds in the Mc-GRATH® MAC video laryngoscope and 103.0±58.3 seconds in the Macintosh laryngoscope, p = 0.917). This suggests that easy visualisation does not necessarily translate to ease of intubation amongst operators. This is possibly attributed to the poor alignment of the oral pharyngeal and laryngeal axis when using a video laryngoscope. A video laryngoscope allows for visualization without good alignment of the axis due to the larger viewing angle. However, in order to achieve intubation, a good alignment is required especially if the endo-tracheal tube is bent to a preformed curvature. This problem can possibly be alleviated by using different preformed curvatures of the endo-tracheal tube.

This study, being a randomised control trial on the efficacy of the study devices in situations of difficult airway managed by a novice user, would be difficult to conduct in a clinical setting. This is due to rare occurrence of a difficult airway being managed by a novice operator and the ease of timely randomisation. Hence, the study was conducted on a high-fidelity patient simulator instead. However, this also contributes to the limitations of the study because the use of a manikin may not replicate the exact conditions of a difficult airway in real life situations. In the simulated difficult airway scenario, the basis of difficulty was a programmed reduction in oropharyngeal space by inducing 'maximum tongue inflation'. However, in clinical practice, the causes of a difficult airway are manifold, including but not limited to reduced mouth-opening, limited head and neck mobility, altered anatomy, awkward dentition, bleeding and secretions. Condensation occurring on the tip of

the video laryngoscope blade may also impair the transmission of clear images on screen.

Based on the results, C-MAC® video laryngoscope would be the best tracheal intubating device. But the design of the device requires the video screen to be mounted, reducing its portability. The blades of the C-MAC® video laryngoscope are not disposable, hence there will be a significant time required for cleansing of the blades before it can be used for the next patient.

4. CONCLUSION

The C-MAC video laryngoscope provides the highest success rate among the novice operator however the design does not allow it to be easily transported to remote locations and there is also a significant turnover time before it can be used for another patient. The McGRATH® MAC showed a comparable success rate of intubation as compared to the conventional Macintosh scope. Thus, with its ease of intubation, reduction in the number of oesophageal intubation, and convenience in terms of quick turnover time and portability, it may be the preferred choice of equipment to be used by novice users in locations situated away from the operating theatre. This device may be useful for users such as junior physicians or nurse practitioners who do not have sufficient experience in trachea intubation especially when expert help is not easily or readily available.

We recommend further clinical studies to evaluate the efficacy of the McGRATH® MAC video laryngoscope in live subjects, and amongst experienced hands.

CONSENT

All authors declare that written informed consent was obtained from the medical students for publication of this study.

ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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