Comparative Effectiveness of the C-MAC Video Laryngoscope versus Direct Laryngoscopy in the Setting of the Predicted Difficult Airway

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ABSTRACT

Background: Video laryngoscopy may be useful in the setting of the difficult airway, but it remains unclear if intubation success is improved in routine difficult airway management. This study compared success rates for tracheal intubation with the C-MAC® video laryngoscope (Karl Storz, Tuttingen, Germany) with conventional direct laryngoscopy in patients with predicted difficult airway.

Methods: We conducted a two-arm, single-blinded randomized controlled trial that involved 300 patients. Inclusion required at least one of four predictors of difficult intubation. The primary outcome was successful tracheal intubation on first attempt.

Results: The use of video laryngoscopy resulted in more successful intubations on first attempt (138/149; 93%) as compared with direct laryngoscopy (124/147; 84%), $P = 0.020$. Cormack-Lehane laryngeal view was graded I or II in 139/147 of C-MAC attempts versus 119/147 in direct laryngoscopy attempts ($P < 0.01$). Laryngoscopy time averaged 46 s (95% CI, 40–51) for the C-MAC group and was shorter in the direct laryngoscopy group, 33 s (95% CI, 29–36), $P < 0.001$. The use of a gum-elastic bougie and/or external laryngeal manipulation were required less often in the C-MAC intubations (24%, 33/138) compared with direct laryngoscopy (37%, 46/124, $P = 0.020$). The incidence of complications was not significantly different between the C-MAC (20%, 27/138) versus direct laryngoscopy (13%, 16/124, $P = 0.146$).

Conclusion: A diverse group of anesthesia providers achieved a higher intubation success rate on first attempt with the C-MAC in a broad range of patients with predictors of difficult intubation. C-MAC laryngoscopy seems to be a useful technique for the initial approach to a potentially difficult airway.

What We Already Know about This Topic

• Video laryngoscopy is advantageous over conventional direct laryngoscopy in novices across various airway scenarios and as a rescue intubation device
• Potential usefulness in skilled hands to manage difficult airways is unknown

What This Article Tells Us That Is New

• In 300 patients with various predicted difficult airways, skilled providers achieved higher success rates for tracheal intubation on the first attempt with C-MAC video laryngoscope (93%) than direct laryngoscopy (84%)

The use of rigid video laryngoscopy is now advocated by many practitioners to manage the difficult airway. Previous studies have demonstrated that video laryngoscopes improve laryngeal view and ease intubation difficulty.1–5 Studies have further established that laryngeal view is improved compared with direct laryngoscopy across various airway scenarios, and particularly novices have demonstrated improved success rates with video laryngoscopy compared with direct laryngoscopy in the routine airway.6–8 We and others have shown that video laryngoscopes offer a useful rescue when direct laryngoscopy has failed.9–11

However, for the experienced provider it is unclear if video laryngoscopy can increase intubation success, particularly in the predicted difficult airway. Several authors have suggested that the patient with predictors of difficult direct laryngoscopy may benefit from the improved laryngeal view rendered on the screen when using video technology compared with direct laryngoscopy.12,13,14 While intubation conditions are favorable and success rates high utilizing these video laryngoscopes, the studies have limited interpretative

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value. They are limited either by selection of isolated predictors of difficulty, artificial difficult intubation conditions, or very small provider population. Thus, it remains unknown whether video laryngoscopy provides benefit for the management of the predicted difficult airway in the everyday routine when used among a large group of patients and providers. It is particularly unclear whether a video laryngoscope provides a higher success rate at initial intubation attempt as compared with conventional laryngoscopy, which is a highly relevant question for the anesthesiologists as increased laryngoscopy attempts are associated with morbidity and mortality.15,16

The C-MAC® is a modification of the Storz Berci-Kaplan DCI® video laryngoscope (Karl Storz, Tuttlingen, Germany). This portable video laryngoscope features standard Macintosh blade designs with a complementary metal oxide semiconductor video chip at the tip of the blade that extends a 60° optical axis in the vertical plane to a video display monitor. This new device has been described in small patient series, in patients with normal airway anatomy, and in an otolaryngology population, but has not been evaluated in a randomized controlled trial for its role in the management of the difficult airway.5,17–21 This study was designed to determine the comparative effectiveness of the C-MAC in a large patient and provider population compared with direct laryngoscopy in the predicted difficult airway. Our hypothesis was that the C-MAC results in a higher intubation success compared with direct laryngoscopy in this challenging patient population.

Materials and Methods

The study protocol was reviewed and approved by the institutional review board of Oregon Health & Science University (Portland, Oregon) and was preregistered online as NCT00956592.14 Written informed consent was obtained from 300 surgical patients who presented for procedures that required general anesthesia with tracheal intubation and who were identified to have validated predictors of difficult direct laryngoscopy. The study was designed as a single-blind, two parallel arm, randomized controlled trial comparing the C-MAC video laryngoscope with direct laryngoscopy (DL, Heine Inc, Dover, NH), both equipped with a Macintosh blade size #3 or #4, in patients with predictors of difficult direct laryngoscopy in a large anesthesia practice of an academic institution.

Patient Selection

Patients were enrolled from various surgical and procedural areas in one university hospital system from October 2009 to December 2010 (Oregon Health & Science University, Portland, Oregon). C-MAC video laryngoscopes were available for clinical use in this institution since July 2009. Providers were given didactic instruction on the proper use of the C-MAC and were afforded the opportunity to use the device for clinical use in the 3 months preceding the study. Patient records were screened from preoperative evaluation history and physical examination for predictors of difficulty among 30,664 potential subjects. Patient recruitment was conducted by the investigators and a study nurse. When possible, potential subjects were contacted by phone before surgery. Patients were included if one or more of the following objective predictors of potentially difficult tracheal intubation were identified: reduced cervical motion either from pathologic conditions or cervical spine precautions (limited capacity to flex or extend the neck or managed with a cervical collar, but with negative imaging); Mallampati classification score of III or IV; reduced mouth opening (less than 3 cm); or history of difficult direct laryngoscopy. The latter criteria was considered positive if previous anesthesia records demonstrated more than two direct laryngoscopy attempts until successful tracheal intubation, failed direct laryngoscopy rescued by another means, or if the patient received a written or verbal communication from an anesthesiologist that tracheal intubation had failed with direct laryngoscopy alone. The following criteria resulted in exclusion of patients from the study: a documented easy tracheal intubation (success on first attempt); a history of failed intubation and failed bag-mask ventilation; known unstable cervical spine injury; age younger than 18; or presentation for an emergency surgical procedure.

Randomization was performed in a 1:1 allocation ratio via specialized computer software.# Individual randomization cards were placed in concealed envelopes. The patients remained blinded about their intubation technique until a postoperative assessment was complete. Both the study team and the anesthesia team remained blinded until the patient entered the operating room at which time the randomization envelope was opened. One of the investigators or a study nurse followed each patient into the operating room to record the relevant intubation and postintubation data.

Anesthetic Management

All patients were preoxygenated in the supine “sniffing” position with the exception of obese patients (body mass index more than 35) and those with cervical spine precautions. Obese patients were placed in a ramped position with a foam ramp or towels to a desired horizontal alignment of the sternal notch with the external auditory meatus. Those with cervical spine precautions were managed with manual in-line stabilization. Induction of anesthesia was at the discretion of the attending anesthesiologist, but included the use of neuromuscular blockade with succinylcholine or a nondepolarizing agent. Patients were deemed to be adequately relaxed with succinylcholine at resolution of fasciculations or after 90 s. Adequate relaxation after nondepolarizing neuromuscular blocking agent was determined at termination of twitchs that were elicited by continuous repeat neurostimu-
lation at the ulnar nerve at 1/s (DigiStimIII, CCR Medical, St. Petersburg, FL).

Laryngoscopy was performed by attending anesthesiologists, certified registered nurse anesthetists, and anesthesia residents with more than 6 months of anesthesia experience. Nonanesthesia providers, medical students, and other trainees were excluded from participation in the study. Certified registered nurse anesthetists and anesthesia residents were under the medical direction of an attending anesthesiologist who assisted with the intubation procedure. During induction of anesthesia, a C-MAC device and conventional laryngoscopes were available. The selection of either a size #3 or #4 blade was at the discretion of the laryngoscopist.

**Outcome Measures**
The primary outcome measure was intubation success at first attempt. Secondary outcome measures included: best Cormack-Lehane laryngeal view, laryngoscopy time, use of external laryngeal manipulation or gum-elastic bougie, arterial oxygen desaturation by pulse oximetry, and airway-related complications.

Intubation success was defined as confirmation of endotracheal tube placement by end-tidal carbon dioxide with a single blade insertion. Removal of the laryngoscope from the mouth constituted a failure. For patient safety, the failed attempt was subsequently managed at the discretion of the attending anesthesiologist with any device, and subsequent attempts were not controlled by the study design; however, the chosen technique was recorded. The provider reported their best laryngeal view obtained on the modified Cormack-Lehane scale. For those randomized to C-MAC, the provider reported the best view either directly (naked eye) or on the video screen. Laryngoscopy time was defined as the time between blade insertion into the mouth and inflation of the endotracheal tube cuff. The study team recorded the following additional information: any oxygen desaturation below 90%, the number of laryngoscopy attempts, trauma noted by the laryngoscopist, use of a gum-elastic bougie, and the use of external laryngeal manipulation. External laryngeal manipulation was defined as any manual external manipulation of the glottis intended to improve laryngeal view or endotracheal tube passage. Further, the study team examined the patient’s airway after successful tracheal intubation for lip or gum laceration, dental injury, pharyngeal injury, or bloody secretions.

Upon arrival to the recovery area, a recovery room nurse served as a blinded safety assessor. The nurse further examined the airway for any signs of trauma (lip/gum lacerations, dental injury, and pharyngeal injury), asked the patient if they noted a sore throat, and asked the patient to grade the intensity of the sore throat. The patient subjectively reported the intensity of the soreness on a three-point scale as mild, moderate, or severe. An assessment sheet was used to document the results, and the nurse finally signed a statement confirming that s/he had no knowledge about the laryngoscopy technique. Patients who remained ventilated at the end of surgery were evaluated by an intensive care nurse after extubation according to the same protocol. Complications were further reviewed by the study team by reviewing inpatient and outpatient electronic medical records (Epic, Madison, WI) for occurrence of delayed or persistent airway trauma (sore throat, bruising, stridor, dental injury, pharyngeal injury, or reintubation). These data were reviewed during the first week of hospitalization or during the first postoperative surgeon clinic visit. Evidence compiled for complications from the various evaluation methods (blinded-safety assessment, observations during laryngoscopy, and manual chart review) was summated for each patient. One author (MA) served as an investigator-monitor for the study.

**Statistical Analysis**
A power analysis was conducted to determine sample size. From existing electronic chart data (Centricity, GE, Washueka, WI), the incidence of multiple laryngoscopy attempts was found to be 15% in a patient population with predictors of difficult direct laryngoscopy, and 5% in patients with normal airways at our institution. The hypothesis of this investigation was that application of C-MAC could correct this difference. Based on that data and the aim of detecting the hypothesized difference (10%) with 80% power at 0.05 significance, 141 patients per treatment group were needed. Therefore, the study was designed to enroll a total of 300 patients.

Data were compiled into a spreadsheet and statistical analyses were performed using SAS 9.1.3 (SAS Institute Inc., Cary, NC). Descriptive statistics were performed on all patient variables. A chi-square or Fisher exact test was used to compare categorical variables, and a two-sample t test was used to compare continuous variables between the two laryngoscopy groups. Statistical significance for all measures was deemed at P < 0.05 based on two-sided tests.

**Results**

**Descriptive Statistics and Population Characteristics**
Three hundred patients were consented and enrolled in this randomized controlled study. There were four randomization failures that were excluded from analysis. In three cases, the anesthesia team deviated from randomization to DL and intubated with a video laryngoscope because of provider preference. Two of these patients were intubated successfully on first attempt with the C-MAC. The other patient was intubated with a Glidescope® (Verathan, Bothell, WA) after two attempts. In one case, the C-MAC device became unavailable during airway management because of sterile processing, so the patient was intubated with direct laryngoscopy after two attempts. One case deviated from the protocol by avoiding neuromuscular blockade. The trachea was successfully intubated per randomization technique (DL) and remained included for evaluating outcomes.
further analysis. Two hundred ninety-six cases were subsequently analyzed (fig. 1). The patients' preoperative anthropometric details are summarized in table 1.

The distribution of the patient characteristics were well balanced between the two treatment groups, with the exception of a greater proportion of patients with a reduced thyromental distance, and fewer resident providers in the C-MAC group. The 296 airway management procedures were provided by a total of 91 individual anesthesia providers, including 13 attending anesthesiologists, 45 experienced resident anesthesiologists, and 33 certified registered nurse anesthetists.

**Intubation Success**

The proportion of success was 93% (138/149, 95% CI, 87–96%) in the C-MAC group, significantly higher than in the DL group (84%, 124/147, 95% CI, 78–90%), \( P = 0.026 \).

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**Table 1.** Patient Demographics, Preoperative Predictors, and Randomization

<table>
<thead>
<tr>
<th>Patient Characteristic</th>
<th>C-MAC (n = 149)</th>
<th>Direct Laryngoscopy (n = 147)</th>
<th>( P ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean ± SD</td>
<td>54 ± 14</td>
<td>55 ± 15</td>
<td>0.387</td>
</tr>
<tr>
<td>Sex male (%)</td>
<td>74 (50)</td>
<td>83 (56)</td>
<td>0.241</td>
</tr>
<tr>
<td>Body mass index, mean ± SD</td>
<td>34 ± 10</td>
<td>34 ± 10</td>
<td>0.453</td>
</tr>
<tr>
<td>ASA class</td>
<td></td>
<td></td>
<td>0.800</td>
</tr>
<tr>
<td>I (%)</td>
<td>3 (2)</td>
<td>2 (1)</td>
<td></td>
</tr>
<tr>
<td>II (%)</td>
<td>60 (40)</td>
<td>53 (36)</td>
<td></td>
</tr>
<tr>
<td>III (%)</td>
<td>80 (54)</td>
<td>87 (59)</td>
<td></td>
</tr>
<tr>
<td>IV (%)</td>
<td>6 (4)</td>
<td>5 (3)</td>
<td></td>
</tr>
<tr>
<td>Thyromental distance &lt;6 cm (%)</td>
<td>28 (19)</td>
<td>11 (8)</td>
<td>0.004*</td>
</tr>
<tr>
<td>Cervical motion limited (%)</td>
<td>40 (27)</td>
<td>40 (27)</td>
<td>0.943</td>
</tr>
<tr>
<td>Neck pathology</td>
<td></td>
<td></td>
<td>0.503</td>
</tr>
<tr>
<td>Mass/scar/radiation (%)</td>
<td>2 (1)</td>
<td>5 (3)</td>
<td></td>
</tr>
<tr>
<td>Thick/Obese (%)</td>
<td>59 (40)</td>
<td>58 (40)</td>
<td></td>
</tr>
<tr>
<td>History of difficult airway (%)</td>
<td>7 (5)</td>
<td>8 (5)</td>
<td>0.770</td>
</tr>
<tr>
<td>Surgical site: neck/airway (%)</td>
<td>31 (21)</td>
<td>34 (23)</td>
<td>0.629</td>
</tr>
<tr>
<td>Tracheal tube route nasal (%)</td>
<td>6 (4)</td>
<td>3 (2)</td>
<td>0.320</td>
</tr>
<tr>
<td>Neuromuscular blockade succinylcholine (%)</td>
<td>93 (62)</td>
<td>90 (61)</td>
<td>0.710</td>
</tr>
<tr>
<td>Provider</td>
<td></td>
<td></td>
<td>0.005*</td>
</tr>
<tr>
<td>Attending (%)</td>
<td>10 (7)</td>
<td>12 (8)</td>
<td></td>
</tr>
<tr>
<td>Resident (%)</td>
<td>67 (45)</td>
<td>91 (62)</td>
<td></td>
</tr>
<tr>
<td>CRNA (%)</td>
<td>72 (48)</td>
<td>44 (30)</td>
<td></td>
</tr>
</tbody>
</table>

* Statistically significant.

ASA = American Society of Anesthesiologists; CRNA = certified registered nurse anesthetist.
This difference represents a 52% reduction of failure to intubate the trachea on first attempt. The significant relationship remained after adjusting for the reduced thyromental distance and provider variables since these two variables were not balanced after randomization (P = 0.012).

Further intubation details including subgroup analysis are summarized in table 2. For patients with a history of known difficult intubation the success rates were similar, 5/7 versus 5/8 (P = 0.714). Certified registered nurse anesthetists achieved a 90% success with C-MAC (65/72) versus 82% success with DL (36/44), P = 0.188. Resident anesthesiologists achieved a better success rate with C-MAC (96%, 64/67) versus 86% success rate with DL (36/44), P = 0.043. Attending anesthesiologists achieved a 90% success rate with C-MAC (9/10) versus 83% success rate with DL (10/12), P = 0.650.

**Intubation Conditions and Adjuncts**

Intubations were analyzed for ease or difficulty based upon the laryngeal view achieved and need to provide external laryngeal manipulation and/or facilitation with a gum-elastic bougie. Figure 2 illustrates that providers achieved an improved laryngeal view with the C-MAC (P = 0.001). Cormack-Lehane laryngeal view was graded I or II in 139/149 of C-MAC attempts versus 119/147 of DL attempts (P < 0.001). The use of a gum-elastic bougie and/or external laryngeal manipulation were required less often in the successful C-MAC intubations (24%, 33/138) compared with successful DL (37%, 46/124, P = 0.020).

**Laryngoscopy Time**

Among the successful intubations laryngoscopy time averaged 46 s (95% CI, 40–51) for the C-MAC group and was shorter in the DL group, 33 s (95% CI, 29–36, P < 0.001). Intubation times among the failures were not measured as this outcome was not controlled.

**Analysis of Failures**

There were a total of 34 failures with the primary intubation approach. Interestingly, there were a similar number of tracheas in each group that could not be intubated despite an adequate laryngeal view (Cormack-Lehane grade I or II). These failures were associated with achieving an adequate laryngeal view in the C-MAC group in 6/11 cases (54%) as compared with the DL group in 8/23 cases (35%). Rescue strategies after intubation with the primary randomized technique were decided according to provider preference, and all resulted in successful intubation of the trachea. In the major-
ity of these cases the same technique was successful on second attempt, whereas other failures were successfully managed by applying video laryngoscopy or flexible fiberoptic intubation. The respective data are summarized in figure 1.

Analysis of Complications
Complications are summarized in table 3. Blinded safety assessments were reported for 90% of cases (267/296). Analysis of complications was reported among the successful intubations and the entire sample. The incidence of dental trauma, sore throat, sore throat severity, and oxygen desaturation were not significantly different between the two groups. No study subject suffered any neurologic or cardiac complications. No patient was reintubated for airway-related complications. No patients suffered any pharyngeal injuries.

Discussion
This is the first study to compare intubation success with video laryngoscopy with direct laryngoscopy in a diverse difficult airway patient population and among a large group of anesthesia providers. In this routine clinical care environment, intubation success in the predicted difficult airway was higher with the C-MAC (93%) compared with direct laryngoscopy using a conventional Macintosh blade (84%). Laryngeal views were better and maneuvers to facilitate intubation were less with the C-MAC. Laryngoscopy time was longer with the C-MAC and intubation-related trauma was similar for both devices.

The higher intubation success rate noted in the C-MAC group is highly relevant. The success rate of direct laryngoscopy in this study (84%) was similar to our expected rate of success (85%) from database review. Reported first attempt success rates in case series for other video laryngoscopes in the setting of the predicted difficult intubation range from 72% to 99%. However, these reports have been limited either by their retrospective study design, small sample of patient predictors, or lack of comparative controls. In contrast, this study tested intubation success of two devices in a prospective randomized fashion and in a clinically relevant environment to demonstrate a success rate of 93% on first attempt utilizing the C-MAC.

Two randomized controlled studies have compared video laryngoscopy with direct laryngoscopy in the patient with a predicted difficult airway. However, both these trials have evaluated other video laryngoscopes (Storz Berci-Kaplan DCI®, Glidescope® Verathon, Bothell, WA, and Pentax AWS® Hoya Corporation, Tokyo Japan). In addition, the studies involved a smaller range of potential difficulty, and smaller provider groups of only two or three skilled video laryngoscopists. In contrast, the data discussed here represents a broad range of potential airway difficulties and covered a broad surgical patient population. Moreover, the performance of 91 anesthesia providers was recorded in this study. Therefore, our study results have a high degree of validity as they reflect the performance of the two devices under routine anesthesia practice conditions, which involve a diverse group of providers treating a large variety of patients with predicted difficult airways.

Improvement of laryngeal views as observed in this study has been described previously by the others. However, despite the repeated finding that video laryngoscopy improves view, a good laryngeal view does not always guarantee intubation success. For example, although they improve laryngeal views, video laryngoscopes with acutely

<table>
<thead>
<tr>
<th>Complication</th>
<th>C-MAC</th>
<th>Direct Laryngoscopy</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lip/gum/oral trauma among successful intubations (%)</td>
<td>20/138 (14)</td>
<td>13/124 (10)</td>
<td>0.311</td>
</tr>
<tr>
<td>Lip/gum/oral trauma in all cases (%)</td>
<td>26/149 (18)</td>
<td>18/147 (13)</td>
<td>0.329</td>
</tr>
<tr>
<td>Dental trauma among successful intubations (%)</td>
<td>1/137 (1)</td>
<td>0/124 (0)</td>
<td>0.342</td>
</tr>
<tr>
<td>Dental trauma all cases (%)</td>
<td>1/149 (1)</td>
<td>0/147 (0)</td>
<td>0.320</td>
</tr>
<tr>
<td>Oxygen desaturation among successful intubations (%)</td>
<td>4/137 (3)</td>
<td>3/124 (2)</td>
<td>0.810</td>
</tr>
<tr>
<td>Oxygen desaturation all cases (%)</td>
<td>8/147 (5)</td>
<td>7/149 (5)</td>
<td>0.812</td>
</tr>
<tr>
<td>Any complications among successful intubations (%)</td>
<td>27/137 (20)</td>
<td>16/124 (13)</td>
<td>0.146</td>
</tr>
<tr>
<td>Any complication all cases (%)</td>
<td>35/147 (23)</td>
<td>26/149 (18)</td>
<td>0.217</td>
</tr>
<tr>
<td>Sore throat among successful intubations</td>
<td>0.817</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mild (%)</td>
<td>33/120 (28)</td>
<td>27/116 (23)</td>
<td>—</td>
</tr>
<tr>
<td>Moderate (%)</td>
<td>12/120 (10)</td>
<td>11/116 (10)</td>
<td>—</td>
</tr>
<tr>
<td>Severe (%)</td>
<td>1/120 (1)</td>
<td>2/116 (2)</td>
<td>—</td>
</tr>
<tr>
<td>None (%)</td>
<td>74/120 (62)</td>
<td>76/116 (66)</td>
<td>—</td>
</tr>
<tr>
<td>Sore throat all cases</td>
<td>0.792</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mild (%)</td>
<td>38/131 (29)</td>
<td>33/136 (29)</td>
<td>—</td>
</tr>
<tr>
<td>Moderate (%)</td>
<td>14/131 (11)</td>
<td>13/136 (10)</td>
<td>—</td>
</tr>
<tr>
<td>Severe (%)</td>
<td>3/131 (2)</td>
<td>3/136 (2)</td>
<td>—</td>
</tr>
<tr>
<td>None (%)</td>
<td>76/131 (58)</td>
<td>87/136 (64)</td>
<td>—</td>
</tr>
<tr>
<td>Any sore throat documentation among successful intubations (%)</td>
<td>48/138 (40)</td>
<td>43/124 (37)</td>
<td>0.607</td>
</tr>
<tr>
<td>Any sore throat documentation all cases (%)</td>
<td>57/147 (44)</td>
<td>52/149 (38)</td>
<td>0.355</td>
</tr>
</tbody>
</table>
curved blades (e.g., Glidescope®) still carry the risk of failure, likely because of difficulty with alignment of the endotracheal tube with the orotracheal axis.3,11 In fact, the data presented here demonstrates that failure to intubate the trachea while achieving an adequate laryngeal view occurred with similar frequency in the C-MAC group (6/11) and in the DL group (8/23). In other words, the chance of failing tracheal intubation despite an adequate laryngeal view was similar for both devices. Therefore, the overall higher success rate afforded by the C-MAC in this study is likely related to the anterior extension and magnification of laryngeal view that is displayed on the screen, which is not available during conventional direct laryngoscopy. In addition, unlike the more curved blade designs as featured in other video laryngoscopes, the C-MAC #3 and #4 blades resemble a standard Macintosh blade. Thus an adequate laryngeal view using a C-MAC blade provides the laryngoscopist with a more comfortable passage that is similar to direct laryngoscopy. We believe that this discussion calls for comparative studies of different video laryngoscopes to determine which device designs would result in the best intubation success rates.

The capacity of the C-MAC to reduce the need for adjunctive intubation maneuvers expands the evidence on the superior performance of video laryngoscopy compared with conventional direct laryngoscopy. Although existing literature demonstrates a reduction in the number of optimization maneuvers and a reduction in intubation difficulty scale score with the Glidescope®, Storz Berci-Kaplan DCI® scope, and Pentax AWS®, a systematic analysis of bougie-facilitated intubation with video laryngoscopy has never been conducted as part of a randomized trial. Our data demonstrates that tracheal intubation with the C-MAC required less external laryngeal manipulation or use of a gum-elastic bougie, and suggests that better laryngeal view and familiar blade curvature of the C-MAC blades eased intubation difficulty.

The slower intubation time with the C-MAC system (13 s) did not appear clinically relevant because arterial oxygen desaturation was not different between groups. Other studies of video laryngoscopes similarly have demonstrated slightly longer intubation times compared with direct laryngoscopy of 3–16 s.2,25

This study is also the first to systematically evaluate complications associated with video laryngoscopy in a comparative trial. Existing case reports warn of the particular risk of oropharyngeal trauma associated with video laryngoscopy. We noted no pharyngeal injuries in this study although those have been observed with other video laryngoscopes.17,27–34 The incidence of complications, such as lip trauma, dental trauma, pharyngeal injury, tracheal injury, or sore throat, were not different following the use of either the C-MAC device or direct laryngoscopy.

Our study has some limitations. First, we selected only four out of many possible predictors of difficult direct laryngoscopy, because those four represent frequently encountered scenarios to the everyday anesthesiologist and are well established.35,36 This design was intentionally chosen to limit variability in the sample, and to provide clinical relevance to the resulting data set. As a result, the study design resulted in two well matched samples. As expected, we observed that several other predictors of difficult intubation were identified in the study population, such as reduced thyromental distance and neck pathology and that data are summarized in table 1. Second, the study was designed to determine which technique is the most appropriate first choice that should be used to manage a difficult airway. Therefore, the measure of success was limited to one intubation attempt. The inclusion of further intubation attempts was not chosen for patient safety, because increased laryngoscopy attempts are associated with morbidity and mortality in the difficult airway,15,16 and we wanted to ensure that the technique for any additional intubation attempt was at the discretion of the anesthesia provider and not determined by the study design. Third, though it is feasible that the increased laryngoscopy time noted with successful C-MAC intubations was related to time consumed confirming laryngeal view on a video screen, it is possible that the prolonged time may have contributed to the observed increased intubation success. Fourth, although providers were experienced with direct laryngoscopy, their exposure to the C-MAC system was recent. As these C-MAC blade designs resemble a Macintosh laryngoscope, the concept of the laryngoscopy technique using the C-MAC was intuitively familiar to providers. Despite the limited exposure to the C-MAC, its use resulted in a higher success rate while managing a difficult airway in our study population, which suggests easy adaptability of the C-MAC system into routine clinical practice.

In summary, the use of the C-MAC video laryngoscope in the setting of a predicted difficult airway resulted in a higher success rate of tracheal intubation compared with direct laryngoscopy. The results from this study are highly relevant because the two techniques were compared involving a diverse difficult airway population from a large practice managed by many experienced laryngoscopists. This data provides evidence for the clinical effectiveness of video laryngoscopy in managing the difficult airway in routine anesthesia care.

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