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Original Contributions

THE C-MAC® VIDEO LARYNGOSCOPE IS SUPERIOR TO THE DIRECT LARYNGOSCOPE FOR THE RESCUE OF FAILED FIRST-ATTEMPT INTUBATIONS IN THE EMERGENCY DEPARTMENT

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☐ **Abstract—Objective: To compare the effectiveness of the C-MAC® video laryngoscope (CMAC) to the direct laryngoscope (DL) when used to rescue a failed first attempt intubation in the emergency department (ED). Methods: Data were prospectively collected on all patients intubated in an academic ED center over a five-year period from February 1, 2009 to January 31, 2014 when both the CMAC and the DL were available. Following each intubation the operator completed a continuous quality improvement (CQI) form documenting patient, operator and intubation characteristics. All orotracheal intubations attempted by emergency physicians (EPs) on adult patients with a failed first intubation attempt, and in which the CMAC or the DL was used for the second attempt, were included. The primary outcome was successful intubation on the second attempt using either the CMAC or the DL. A multivariate logistic regression analysis was performed to adjust for potential confounders. Results: During the five-year study period, there were 460 adult orotracheal intubation attempts by EPs which were not successful on the first attempt. In 398 (86.5%) of these cases the same operator performed the second attempt. The CMAC was utilized for the second attempt in 141 cases and was successful in 116 (82.3%; 95% CI 75.0%-88.2%) and the DL was utilized in 94 cases and was successful in 58 (61.7%; 95% CI 51.1%-71.5%). In a multivariate logistic regression analysis the CMAC was associated with an increased odds (adjusted OR 3.5; 95% CI 1.9-6.7) of a second attempt success compared to the DL. Conclusions: After a failed first intubation attempt in the ED, regardless of the initial device used, the CMAC was more successful than the DL when used for the second attempt. This suggests that the CMAC is the preferred rescue device after an initial intubation attempt in the ED fails.** © **2014 Elsevier Inc.**

☐ **Keywords—Emergency Intubation; Video Laryngoscopy; Failed Intubation; Rescue Intubation**

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INTRODUCTION

Since the C-MAC® video laryngoscope (CMAC) (Karl Storz, Tuttlingen, Germany) was introduced into clinical practice, it has been used with increasing frequency for emergency intubations (1–6). To date, the existing literature on the CMAC for emergency intubations has evaluated its role as a primary intubating device. No studies have determined its efficacy for rescue intubation attempts in the emergency department (ED).

Establishing a definitive airway is a crucial step in the stabilization of critically ill or injured patients presenting

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to the ED. Studies have demonstrated the incidence of complications such as aspiration, hypoxemia, hemodynamic instability, and death increase with each intubation attempt (7–9). Successfully securing the airway in the fewest number of attempts is crucial to minimize complications and provide optimal care to ED patients. However, there are no ED studies demonstrating which airway device is most effective after a failed first attempt intubation. It is important for emergency physicians (EPs) to know which airway device will be most successful for a rescue intubation after a failed first attempt. The goal of this study was to compare the CMAC with the direct laryngoscope (DL) to determine which device is most successful when used for a rescue attempt after a failed initial intubation attempt. The primary outcome was successful intubation on the second attempt, by the same operator, when using either the CMAC or the DL for this rescue intubation attempt.

METHODS

Study Design and Setting

This is a single-center analysis of ED intubations performed during the 5-year period of February 1, 2009 to January 31, 2014 recorded in a continuous quality-improvement (CQI) database. This project was granted exemption by the University of Arizona Institutional Review Board.

This study was conducted at a 61-bed tertiary care academic ED and Level I trauma center with an annual census of approximately 70,000 visits. This institution has an Accreditation Council for Graduate Medical Education–accredited 3-year emergency medicine (EM) residency program, as well as a 5-year combined emergency medicine/pediatrics (EM/PEDS) residency program. Only intubations initially attempted by EM residents, EM/PEDS residents, and EM faculty were included in the study.

Selection of Participants

This study only included orotracheal intubations attempted by EPs on adult patients 18 years of age and older with a failed initial intubation attempt in which the CMAC or DL was used for the second attempt.

Although the DL has historically been used as the primary intubation device in our ED, the CMAC was first introduced into our ED on February 1, 2009. Only patients intubated during the 5-year period when both devices were available in the ED were included in this study (February 1, 2009–January 31, 2014).

EM and EM/PEDS residents receive comprehensive emergency airway management training, including instruction on use of the DL and the CMAC, as well as many other advanced airway devices and techniques, such as the GlideScope®, the flexible fiberoptic scope, supraglottic airways, and surgical airway management. Their curriculum includes didactics in the classroom, experience in the simulation laboratory and operating room, and practical experience in the ED. The majority of intubations in this ED are performed by EM and EM/PEDS residents, all under the supervision of the attending EM faculty.

Methods and Measurements

After each ED intubation, a CQI form is completed documenting important clinical information regarding the procedure. Data collected includes information on patient, operator, and procedure characteristics, such as patient age and sex, operator postgraduate year (PGY) and specialty, reason for intubation, reason for device selection, method of intubation, drugs used for intubation, device used on each attempt, outcome of each attempt, and presence of difficult airway characteristics (DACs). The senior investigator reviewed all data forms and any incomplete forms were returned to the operator for completion. Pharmacy records, billing records, and a customized intubation report in the electronic medical record were cross-referenced to identify any missing forms. In the event of a missing form, a blank data form was provided to the operator for completion.

Methods of intubation include rapid sequence intubation (RSI), in which a paralytic was used (usually in conjunction with a sedative agent); awake intubation, where only a sedative was used; and intubation without any pharmacologic agents.

An intubation attempt was defined as insertion of the laryngoscope blade into the patient's mouth, regardless of whether an attempt was made to pass a tracheal tube. A failed intubation attempt was defined as insertion and removal of the laryngoscope without successful placement of a tracheal tube. A successful intubation was defined as appropriate placement of a tracheal tube into the patient's airway as confirmed by standard clinical means, including end-tidal CO_2 capnometry. A successful rescue intubation was defined as a successful intubation on the second attempt by the same operator.

Outcome Measures

The primary outcome was successful rescue intubation on the second attempt by the initial operator using the DL or the CMAC.

Primary Data Analysis

Summary statistics were calculated for patient demographics, intubation characteristics, and operator

characteristics. The 95% confidence intervals for all counts and proportions were calculated using the "exact" method. Multivariate logistic regression analyses were then used to identify confounding factors. The investigators selected the most pertinent confounders based on previous investigations, including the reason for intubation (cardiac arrest vs. noncardiac arrest), number of DACs, and operator level of training (10). The primary independent variable of interest was the device used (CMAC vs. DL) on the rescue attempt. The data were clustered by operator, and this was incorporated into the model. For the purpose of this model, EM/PEDS operators were categorized as follows: EM/PEDS residents in PGY5 were categorized as EMR-3, EM/PEDS residents in PGY3 and PGY4 were categorized as EMR-2, EM/PEDS residents in PGY 1 and 2 were categorized as EMR-1. The model was checked for interactions and the goodness-of-fit of the model was assessed using the Hosmer-Lemeshow test. All analyses were conducted with Stata software, version 13 (College Station, TX).

RESULTS

Characteristics of Study Subjects

A total of 2587 intubations were performed in our ED during the 5-year study period. Of these, 371 intubations were excluded from this study because they were not performed by EPs, were on pediatric patients, or were not orotracheal intubations. This left 2216 oral intubation attempts by EPs on adult patients. Of these, 1756 were successful on the first attempt and were excluded from this analysis. Of the 460 first-attempt failures, 62 involved a change in operator and were also excluded from this analysis. This left 398 cases where the original operator also performed the second intubation attempt. In this cohort, the CMAC was used on the second attempt in 141 cases and the DL was used in 94 cases. (In 163 cases a device other than the CMAC or the DL was utilized for the second attempt, and thus were not included in this analysis.)

The study group included 141 patients in whom the CMAC was used for the second attempt and 94 patients in whom the DL was used for the second attempt. These two groups were fairly evenly matched in terms of patient, operator, and intubation characteristics. The mean patient age was 46.8 years in the CMAC group and 49.2 years in the DL group. In the CMAC group, 73.0% of subjects were male and in the DL group 57.5% were male. Trauma patients accounted for 44.0% of the patients in the CMAC group and 38.3% of the patients in the DL group. RSI was used as the method of intubation in 80.1% of cases in the CMAC group and in 77.7% of cases in the DL group. 82.3% of the patients in the CMAC group had at least one DAC and 75.5% of the patients in the DL group had at least one DAC. The distribution of operators (by PGY) was fairly similar in both the CMAC and the DL groups (Table 1).

Main Results

Of the 398 failed first-attempt intubations in which there was no operator change, the CMAC was used for the second attempt in 141 patients and the DL was used in 94 patients. When the CMAC was used for the second attempt it was successful in 116 patients (82.3%; 95% CI 75.0%–88.2%), regardless of the initial device used. When the DL was used for the second attempt it was successful in 58 patients (61.7%; 95% CI 51.1%–71.5%), regardless of the initial device used (Figure 1).

When the CMAC was used and failed on the initial intubation attempt, operators who continued with the CMAC had a second-attempt success rate of 85.4% (82 of 96) (95% CI 76.7%–91.8%), and operators who switched from the CMAC to the DL had a second-attempt success rate of 50.0% (5 of 10) (95% CI 18.7%–81.3%) (Figure 2A).

When the DL was used and failed on the initial intubation attempt, operators who continued with the DL had a second-attempt success rate of 62.9% (39 of 62) (95% CI 49.7%–74.8%), and operators who switched from the DL to the CMAC for the second attempt had a success rate of 78.4% (29 of 37) (95% CI 61.8%–90.2%) (Figure 2B).

Multivariate Logistic Regression for Second-Attempt Rescue Intubation

In the multivariate regression model, after adjusting for pertinent confounders, the CMAC was associated with a high adjusted odds ratio (aOR) for successful rescue intubation on the second attempt compared to the DL (aOR = 3.5; 95% CI 1.9–6.7). No other variables in this model were significantly associated with rescue attempt success, except for number of DACs (Table 2). No significant interactions were identified and the model fit the data well (Hosmer-Lemeshow goodness-of-fit, $p = 0.395$).

DISCUSSION

Patients requiring tracheal intubation in the ED are at high risk for complications due to their underlying clinical condition and their limited physiologic reserve. It is critical for EPs to secure the airway quickly and with as few attempts as possible. If the first intubation attempt fails, the EP must decide whether to make another attempt with the same airway device or switch to a different device. Unfortunately, there is limited research

Table 1. Characteristics of C-MAC® Video Laryngoscope and Direct Laryngoscope Cohorts

Characteristic	CMAC (%) (n = 141)	95% CI*	DL (%) (n = 94)	95% CI*
Age (y), mean (range)	46.8 (18–90)	43.7–49.9	49.2 (18–88)	45.7–52.7
Male sex, n (%)	103 (73.0)	64.9–80.2	54 (57.5)	46.8–67.6
Medical/trauma, n (%)				
Trauma	62 (44.0)	35.6–52.6	36 (38.3)	28.5–48.9
DACs, n (%)				
None	25 (17.7)	11.8–25.1	23 (24.5)	16.2–34.4
1	40 (28.4)	21.1–36.6	33 (35.1)	25.5–45.6
≥2	76 (53.9)	45.3–62.3	38 (40.4)	30.4–51.1
Reason for intubation				
Airway protection	87 (61.7)	53.2–69.9	56 (59.6)	49.0–69.6
Respiratory failure	20 (14.2)	8.9–21.1	13 (13.8)	7.6–22.5
Cardiac arrest	27 (19.2)	13.0–26.6	20 (21.3)	13.5–30.9
Patient control	7 (5.0)	2.0–10.0	4 (4.3)	1.2–10.5
Hypoxia	0	NA	1 (11.1)	0–5.8
Method of intubation, n (%)				
RSI	113 (80.1)	72.6–86.4	73 (77.7)	67.9–85.6
Sedation only	4 (2.8)	0.8–7.1	1 (1.1)	0–5.8
No medications	24 (17.0)	11.2–24.3	20 (21.3)	13.5–30.9
Paralytic used, n (%)				
Succinylcholine	54 (38.3)	30.2–46.9	39 (41.5)	31.4–52.1
Rocuronium	59 (41.8)	33.6–50.4	34 (36.2)	26.5–46.7
None	28 (19.8)	13.6–27.4	21 (22.3)	14.4–32.1
PGY level of operator, n (%)				
PGY1	35 (24.8)	17.9–32.8	25 (26.6)	18.0–36.7
PGY2	51 (36.2)	28.3–44.7	25 (26.6)	18.0–36.7
PGY3	46 (32.6)	25.0–41.0	37 (39.4)	29.4–50.0
PGY4	6 (4.3)	1.6–9.0	2 (2.1)	0.3–7.5
PGY5	1 (0.7)	0–3.9	2 (2.1)	0.3–7.5
Attending	2 (1.4)	0.2–5.0	3 (3.2)	0.7–9.0
Reason for failed first attempt, n (%)				
Cannot visualize airway	68 (48.2)	39.7–56.8	51 (54.3)	43.7–64.6
Cannot direct tube	45 (31.9)	24.3–40.3	19 (20.2)	12.6–29.8
Cannot pass tube	9 (6.4)	3.0–11.8	3 (3.2)	0.7–9.0
Esophageal intubation	18 (12.8)	0.8–19.4	9 (9.6)	4.5–17.4
Equipment failure	1 (0.7)	0.0–0.4	12 (12.8)	6.8–21.3

CI = confidence interval; CMAC = C-MAC® video laryngoscope; DAC = difficult airway characteristics; DL = direct laryngoscope; NA = not applicable; PGY = postgraduate year; RSI = rapid sequence intubation.
* 95% confidence intervals calculated using "exact" method.

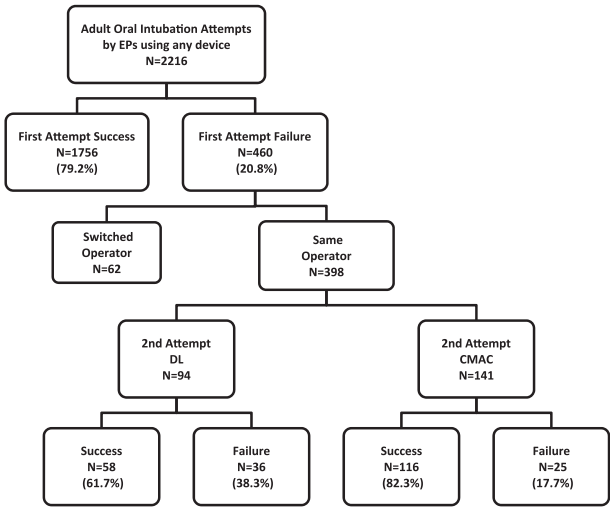

Figure 1. Outcome of failed first-attempt intubation. CMAC = C-MAC video laryngoscope; DL = direct laryngoscope; EP = emergency physician.

to help guide the EP faced with this important decision. These data show that EPs were more successful when they used the CMAC compared to when they used the DL on the rescue attempt after a failed first attempt, regardless of which device they started with. Using a multivariate logistic regression model, we found that EPs that failed their first intubation attempt were more than three times more likely to perform a successful rescue intubation on the second attempt when using the CMAC compared to the DL (independent of the starting device).

When the CMAC was used as the initial intubation device and was unsuccessful, EPs were more successful when they continued with the CMAC for the second attempt rather than switching to the DL. This suggests that the DL is not a good rescue device for failed CMAC video laryngoscopy. Conversely, when the DL was used on the first attempt and failed, operators were more successful when they switched to the CMAC for

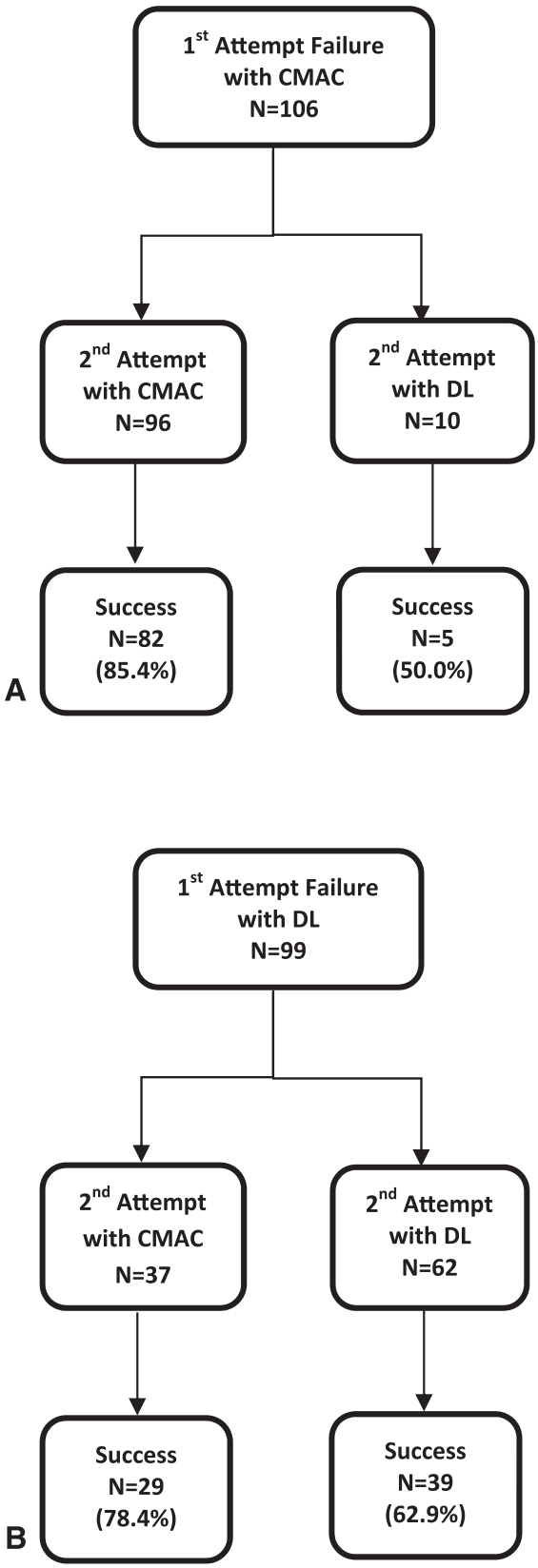

Figure 2. (A) Flow chart for first-attempt C-MAC® video laryngoscope (CMAC) failures. (B) Flow chart for first-attempt direct laryngoscope (DL) failures.

Table 2. Logistic Regression Model for Successful Second-Attempt Intubation

	Second attempt Success		
Variable	Adjusted Odds Ratio	95% CI	*p* Value
Rescue device			<0.001
DL	[Reference]		
CMAC	3.5	1.9–6.7	
Reason for intubation			0.580
Noncardiac arrest	[Reference]		
Cardiac arrest	0.8	0.4–1.7	
No. of DACs	0.7	0.6–0.9	0.002
Operator experience			
EMR-1	[Reference]		
EMR-2	1.0	0.5–2.1	0.915
EMR-3 or Attending	2.0	0.9–4.1	0.073

CI = confidence interval; CMAC = C-MAC® video laryngoscope; DAC = difficult airway characteristic; DL = direct laryngoscope; EMR = emergency medicine resident.

the second attempt rather than continuing with the DL. This suggests that the CMAC is a good rescue device for failed direct laryngoscopy.

There is no available literature on the efficacy of specific airway devices after a failed first attempt in the ED. The current literature describes factors associated with successful rescue intubations, but does not address device selection (11,12). A recent study by Kim et al. evaluated factors associated with successful second and third intubation attempts in the ED and found factors positively associated with a successful second intubation attempt were senior physicians, emergency physicians, nondifficult airways, and the use of RSI (11). A study by Bair et al. evaluated failed intubation attempts in the ED and found that RSI was the most commonly used technique when oral or nasal intubation methods failed (12). Neither of these studies evaluated the role of specific airway devices for rescue intubation.

Several studies have evaluated the use of specific airway devices for rescue attempts in the operating room (13−15). Kilicaslan et al. reported on 42 patients in the operating room with a failed first intubation attempt using the DL and found when the CMAC was used as a rescue device it was 86% successful at achieving intubation on the second attempt, and ultimately was successful in 100% of the cases (13). Their results are comparable to ours, with their increased success likely attributable to the controlled operating room environment and exclusion of patients with difficult airways. Noppens et al., in a series of 61 operating room patients, found the McGrath Series 5® video laryngoscope was able to rescue the DL with a success rate of 62% on the second attempt (14). A study by Maharaj et al.

demonstrated a 100% success rate with the use of the Airtraq® optical laryngoscope as a second attempt rescue device for failed DL in the OR (15). Although performed in different clinical environments from our study, these studies suggest that optical and video laryngoscopes have a significant role for rescue intubations after a failed first intubation attempt.

Limitations

This study has several important limitations. First, this was an observational study and thus the device used for the rescue attempt was not randomly assigned. However, due to the emergent nature of intubations in the ED, especially in the circumstance of a failed intubation attempt, it would be very difficult to randomly assign devices for rescue attempts. Despite the observational nature of this study, Table 1 demonstrates relatively well-matched demographics between the CMAC and DL groups. To account for the possibility of confounders, we used a multiple logistic regression model and, even after controlling for these confounders, we still found the CMAC was a more successful device for rescue intubations. Although these statistical methods were incorporated to account for the limitations of an observational study, the results must still be interpreted with caution, as there may be unknown or unaccounted for confounders present. It should also be acknowledged that the data used in this study were self-reported by the operators after the procedure. Therefore, data may be subject to self-report bias. However, due to the unpredictable nature of ED intubations, it would be logistically very difficult to have a dedicated, unbiased observer record this information. There may also be some selection bias as EPs may select devices based on personal preference or previous experience. Finally, the setting for this study is an academic ED where EPs have extensive training and experience with optical airway devices, including multiple video laryngoscopes. Therefore, these results may not be generalizable to all EPs, some of whom may be less comfortable with video laryngoscopy.

CONCLUSION

In summary, our study is the first to evaluate the efficacy the CMAC as a rescue device for failed first-attempt intubations in the ED. We found that after a failed first intubation attempt in the ED, regardless of the initial device used for this attempt, EPs were more successful on their second attempt when using the CMAC compared to DL. This suggests that EPs should strongly consider using the CMAC for a rescue attempt after a failed initial intubation attempt in the ED.

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ARTICLE SUMMARY

1. Why is this topic important?

Securing the airway of a critically ill or injured patient in the fewest number of attempts possible is crucial to minimize patient complications and improve outcome. However, there are no ED studies demonstrating which device should be used following a failed first attempt intubation.

2. What does this study attempt to show?

This study compares the CMAC video laryngoscope with direct laryngoscopy to determine which device is most successful when used in a rescue attempt after a failed initial intubation attempt.

3. What are the key findings?

Emergency Physicians are more successful in securing the airway after a failed first attempt intubation when they use the CMAC on the rescue attempt than when they use direct laryngoscopy on the rescue attempt.

4. How is patient care impacted?

Patients undergoing intubation in the ED are at high risk for complications due to limited physiologic reserve and their underlying clinical condition, and thus intubation must be achieved in as few attempts as possible. Our study suggests the CMAC is a superior device for rescue intubations in the ED.