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Use of the CMAC Video Laryngoscope for Intubation

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ABSTRACT

The CMAC (Karl Storz, Tuttlingen, Germany) is a portable video-laryngoscope which was originally introduced in 1999 and has a similar blade curvature as the standard Macintosh [MAC] (C blade) and a more angulated blade named D blade. The CMAC is the first Macintosh-typed video-laryngoscope to be introduced into clinical practice since the original version of the video Macintosh (MAC) system in 1999 and has undergone several modifications since it was introduced into clinical practice. The search for an intubating device which would consistently provide for optimal visualization of the glottic structures has involved a wide variety of direct and indirect video-laryngoscopic devices. The importance of the ability to promptly intubate the tracheal on the first attempt cannot be over-emphasized as prolonged apnea times due to delayed tracheal intubation can lead to hypoxemia, cardiac arrest and cerebral ischemia. Avoiding oxygen desaturation during the intubation process is dependent on optimal visualization of the glottis to achieve successful tracheal intubation.

Keywords: Video laryngoscopy (VL), Direct laryngoscopy (DL), CMAC, Endotracheal intubation, Glottic view

INTRODUCTION

The main objective of every anesthesia practitioner is to expeditiously achieve successfully tracheal intubation on the first attempt. The "best indirect airway device" has not been established, however, a variety of video-laryngoscopes are available, including the CMAC® (Karl Storz, Tuttlingen, Germany) [1-8], GlideScope® (Verthon, Bothell, WA, USA) [9-11], McGrath® Series 5 (Aircraft Medical, Edinburgh, UK) [12-14], Airtraq™ (Prodol Meditec SA, Vizcaya, Spain) [15-17], the A.P. Advance™ (Venner Medical SA, Singapore) [16-18], the KingVision™ (Kingsystems, Noblesville, IN, USA) [17,19-21] have been used in clinical studies.

It has been suggested that video-laryngoscopy (VL) can provide significant clinical advantages over direct laryngoscopy (DL), including improved laryngeal visualization, magnification of the airway structures, facilitating the manual manipulation of the airway, and providing a shared view of the glottic opening teaching endotracheal intubation [22]. These devices can also reduce the number of failed intubations, particularly among patients presenting with a "difficult airway" [23,24]. By improving the glottic view, statistically significantly [(Mantel-Haenszel (M-H) odds ratio (OR)] VL devices can reduce laryngeal/airway trauma when used: VL reported fewer laryngeal or airway traumas (M-H OR, random-effects 0.68, 95% CI 0.48 to 0.96; 29 studies; 3110 participants) and fewer incidences of postoperative hoarseness (M-H OR, fixed-effect 0.57, 95% CI 0.36 to 0.88; six studies; 527 participants) [23,25]. The controversy continues regarding the influence of video laryngoscopy on the intubation outcomes in emergency and critically-ill patients. It has been stated that compared with direct laryngoscopy, video laryngoscopy does not improve intubation outcomes in emergency and critical patients [26]. Prehospital intubation success is worse when using a video laryngoscopy, even when performed by experienced operators [26].

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COMPARATIVE STUDIES INVOLVING THE CMAC DEVICE IN THE OPERATING ROOM

CMAC has been reported to be better than the standard Macintosh blade with respect to glottic view and intubation time for intubation in the lateral position in patients without a difficult airway [2]. In one study CMAC showed to be superior to the Bonfils fiberscope with respect to the time required to achieve successful intubation and response to heart rate during the intubation process in ASA I patients scheduled for elective surgery [27]. In another study Ezhar et al. [28] found the Bonfils fiberscope was comparable to C-MAC in regards to hemodynamic responses to tracheal intubation in patients with no difficult airway characteristics (such as Mallampati < 2/Cormack-Lehane grade ≤ II, Patil > 4 cm, mouth opening > 3 cm) undergoing elective surgery. Ahmed et al. [15] compared CMAC to Airtraq in patients undergoing elective surgery founding that both devices were similar with respect to glottic visualization in the neutral position and intubation success. However, the CMAC was superior with respect to intubation time (14.9 ± 12.89 s, vs. 26.3 ± 13.34 s; P=0.0014, respectively) and hemodynamic stability. Bujari and Selvaraj [3] compared CMAC to McCoy and Macintosh laryngoscopes regarding to hemodynamic response to laryngoscopy and endotracheal intubation (heart rate, systolic blood pressure, mean arterial pressure, diastolic blood pressure) in ASA I adult patients undergoing elective surgery; the findings showed that McCoy and Macintosh laryngoscopies had similar hemodynamic response to direct laryngoscopy and endotracheal intubation, but CMAC presented an increased hemodynamic response than conventional Macintosh laryngoscopy and intubation.[3]

Awake upright intubation is another modality in securing airways that can reduce many of the risks associated with traditional intubation [30]. Drenguis and Carlson [9] compared CMAC to GlideScope in regard to glottic view and times to obtain a glottic view in a prospective, randomized, cross-over study of awake upright laryngoscopy on healthy volunteers. The procedure was performed by a third-year emergency resident and one emergency attending physician, under local anesthesia (topical lidocaine, nebulized through a mouthpiece, sprayed lidocaine into the oropharynx through an atomizer and gargled in the posterior pharynx). They found that in healthy volunteers, the GlideScope offered greater views of the glottic opening and shorter times to first view of the glottis than the CMAC during awake upright intubation [9].

Tosh et al. [30] compared the ease of oral intubation with the use of 60° angled styletted endotracheal tube versus that performed over bougie inserted under CMAC D-blade guidance founding that a 60° angled styletted endotracheal tube resulted in easier and faster intubation conditions compared to a bougie. When the CMAC D-blade and the KingVision™ (Kingsystems, Noblesville, IN, USA) were compared in regard to ease of intubation between the 'sniffing' and the neutral position in adult patients scheduled to undergo elective surgery, the results showed there was no significant difference in laryngoscopy time (p=0.2), intubation time (p=0.27) and success rate (p=0.96) between the two groups. The percentage of glottic opening (POGO) score was lower for CMAC D-blade neutral group as compared with other groups (p=0.01). There was no significant difference in the ease of intubation between the 'sniffing' and the neutral position when using the KingVision and the CMAC D-blade video laryngoscopes [19]. Cierniak et al. [12] reported that the CMAC D-blade showed to be better when compared to McGrath Mac, KingVision, The VividTrac® (VT, Vivid Medical, Palo Alto, USA) in regard to the clinical use in almost all technical, mechanical and optical parameters, although in this study VividTrac was considered a better device to train students in the context of clinical practice in real-time due to the possibility of transferring the image on the big screen.

Double-lumen tube (DLT) placement is the gold standard for lung isolation required in thoracic surgeries; its placement is technically more challenging and causes greater hemodynamic disturbance and trauma than single-lumen tube placement even in patients with Cormack Lehane grade 1 view. In a randomized clinical trial by Shah et al. [31] CMAC D-blade proved to be a useful alternative to Macintosh for routine double lumen tube insertion for elective thoracic surgery in oncological patients. The result reported showed the time required for intubation was comparable (32 ± 11 s vs. 37 ± 19, respectively). Number of attempts and incidence of complications (trauma, DLT cuff rupture, esophageal intubation) was greater in the Macintosh group, except malpositioning into the wrong bronchus, which was greater with the D-blade. Greater hemodynamic changes were observed during Macintosh laryngoscopy. CMAC D-blade also has been reported to have significantly reduced the incidence and severity of postoperative sore throat, hoarseness of voice and cough following orotracheal intubation compared to DL with traditional Macintosh blade in adults patients undergoing short elective laparoscopic surgeries lasting <2 h [32].

CMAC and CMAC D-blade has been reported to be used for awake orotracheal intubation in adult healthy volunteers as well in patients with a difficult endotracheal intubation. Gaszyńsk [33] published a case series reporting the intubation of seven patients with neoplasm tumors in larynx presenting a predicted extremely difficult airway. In all cases, awake intubation using CMAC was performed in patients breathing spontaneously, under local anesthesia, with oxygen administered via nasal catheter. The author concluded that CMAC was a very useful tool for anesthesiologists and can be applied not only for unexpected difficult intubation but also for predicted difficult airway, and as an additional diagnosis tool to evaluate the larynx before surgery. The view obtained with the CMAC

corresponded with larynx examination performed before surgery and could potentially reveal more details during the intubation process. Kumar et al. [34] published a case report of a 28 year old male with a restricted mouth opening of just 1.2 cm, fractures of anterior cranial fossa, medial orbital wall and floor, also bilateral maxillary, nasal and left zygomatic bone fractures. The patient received glycopyrrolate 0.2 mg intramuscularly, his oral cavity was anesthetized (by gargling) with lidocaine viscous and a bilateral superior laryngeal nerve block was performed with lidocaine and a transtracheal injection of lidocaine was administered, then a successful awake oral intubation (with a 7 mm internal diameter cuffed endotracheal tube) with the CMAC D-blade was performed. However, in predicted difficult laryngoscopy cases (e.g. obese, large neck circumferences, higher Mallampati scores); the CMAC D-blade did not yield the same first-attempt intubation success rates as the GlideScope [10].

Nasal intubation with traditional Macintosh laryngoscope usually needs the use of Magill's forceps or external laryngeal manipulation; there are few publications regarding the use of CMAC and CMAC D-blade in nasotracheal intubations. Rajan et al. [7] in a prospective, randomized, single-blinded study compared CMAC D-blade to DL with Macintosh laryngoscope in adult patients undergoing head and neck surgeries (such as wide local excision and reconstruction surgeries for carcinoma of tongue, buccal mucosa, alveolus, maxilla and ameloblastoma), requiring nasal intubation. They concluded that CMAC D-blade was superior in view of easier, quicker and less traumatic intubation compared to the use of traditional Macintosh laryngoscope in adults requiring nasal intubation. In another study, Hazarika et al. [8] compared CMAC D-blade to Macintosh laryngoscope for nasotracheal intubation in adult patients with difficult airways undergoing surgeries for head and neck cancer. They found that CMAC D-blade was a better tool in managing difficult airway by nasal route in terms of time taken to intubation, success rate, number of attempts, ease of intubation, use of accessory maneuvers, and trauma. CMAC D-blade has also reported to have some incidence of failed intubation in expected difficult intubation cases; Arslan [35] published two expected difficult intubation cases (Mallampati 4 (with phonation), mandibular protrusion of B, obstructive sleep apnea disorder, male gender and thick neck (>46 cm)) scheduled to be intubated with CMAC D-blade, in both cases the intubating process failed and they were rescued having a successfully intubation with the Airtraq device.

Difficulties with tracheal intubation can arise unexpectedly and impact patient safety, use of video-laryngoscopes may reduce the number of failed intubations, particularly among patients presenting with a difficult airway. The use of a CMAC device improved the glottic view, reduced laryngeal/airway trauma and failed tracheal intubation (OR, random-effects 0.32, 95% CI 0.15 to 0.68; I2=0%; n=1058) [36]. CMAC provides several advantages during the intubation process, but the idea of use it as a routine airway device in all patients still lack adequate evidence and support with respect to reducing the number of intubation attempts or the incidence of hypoxia or respiratory complications, and no evidence as well to support the claim that the use of a video laryngoscope reduces the time required for successful tracheal intubation. In a multicenter randomized controlled trial, the investigators evaluated the performance of three unchannelled VL (C-MAC™ D-blade, GlideScope™ and McGrath™) versus three channelled VL (Airtraq™, A.P. Advance™ difficult airway blade and KingVision™) in adult patients with a simulated difficult airway (application of a cervical collar to limit mouth opening and neck movement). They found that the use of the McGrath and CMAC D-blade, in a simulated difficult airway demonstrated highest success rates and lowest incidence of soft tissue lesion or bleeding [17].

In cases of multiple facial trauma and other specific cases, the anesthesiologist may be asked to convert an oral endotracheal tube to a nasal endotracheal tube or vice versa. Conventionally, the patient is simply extubated and the endotracheal tube is re-inserted along either the oral or nasal route. However, the task of airway management can become difficult due to surgical trauma or worsening of the airway condition [37]. Ji et al. [37] reported the usefulness of CMAC and fiberoptic bronchoscope in two adult patients with facial bone fractures. Their results showed that these two devices were similarly successfully for facilitating nasal-oral tube exchange.

Dubey et al. [38] published a case report of a 60 year old male scheduled for a temporal bone resection, with a Mallampatti grade 2 and other airway parameters within normal limits. During a first failed intubation attempt with a DL Macintosh, he was found to have a Cormack-Lehane III, then a successful intubation was performed in a second attempt using a CMAC D-blade VL with a POGO of 60%. Three days later he had a secondary hemorrhage and was shifted to the operating room in right lateral position with a surgical resident applying compression to the bleeding site. Patient was deteriorating rapidly and there was no time to wait till the bronchoscope could be set up. Thus, an awake CMAC D-blade guided oral intubation was attempted but failed due a limited mouth opening. The airway was finally secured by an awake nasotracheal intubation aided by the Baedeker curved forceps. All this while the patient was lying in the lateral position with the compression to bleeding point continuing. Once the airway was secured, anesthesia was administered and surgery performed. CMAC D-blade aided to a successful awake nasal intubation in lateral position in a patient with documented difficult intubation.

CMAC and CMAC D-blade have been reported that besides tracheal intubation they are also useful tools with the placement of nasogastric tube (NGT). Usually, direct

laryngoscopy guided by Magill forceps is the technique of choice if NGT insertion is unsuccessful with the blind method. The failure rate in the first attempt with the blind method can be as high as 50%. Variations in a patient's functional anatomy, anesthetized, and paralyzed patients, and the presence of endotracheal tube can further complicate an already difficult NGT placement. Although various techniques have been suggested to make NGT insertion easier, failure to insert or NGT malposition still occurs. The most frequent malpositioning of NGT occurs in the respiratory tract [39]. Dharmalingam and Gunasekaran [39] reported a case of a 50 year old man, with no known medical illness who was admitted to intensive care unit for ventilatory support due to traumatic brain injury. After several unsuccessful blind attempts of the NGT placement with direct laryngoscopy and Magill forceps, the CMAC D-blade was very useful for placing the NGT easily and quickly, with less risk of trauma and malposition. The authors suggested that this method should be considered as an option in similar difficult situations.

CERVICAL SPINE INJURIES

Glottic visualization can be difficult with cervical immobilization in patients with cervical spine injury and it is obviously important to carefully perform tracheal intubation to avoid exacerbating the cervical spine injury. Securing the airway with tracheal intubation in a patient population has always been a challenge regardless of whether it is conducted in a controlled operating room environment, a busy emergency department or in the field or other out-of-hospital setting. Shravanalakshmi et al. [20] in a randomized study compared King Vision VL, CMAC and the CMAC D-blade for the tracheal intubation of adult patients with proven or suspected cervical spine injuries scheduled for elective surgery. All patients were placed in cervical spine immobilization/rigid cervical collars; during laryngoscopy cervical immobilization was maintained with Manual in line stabilization with anterior part of cervical collar removed. These investigators concluded all VL systems provided good glottic visualization and a high first attempt success rate in patients with cervical spine injury. However, CMAC insertion was significantly easier than the King Vision device and this better than CMAC D-blade. Ahmed et al. [21] in another prospective, randomized study compared CMAC to King Vision VL in adult patients with no-difficult airway scheduled for elective surgery mimicking a scenario of cervical spine injury with application of manual inline axial stabilization and jaw thrust (applied by an experienced anesthetist holding both the sides of the neck and the mastoid process or preventing extension/flexion or rotational movements of the neck). The result of this study showed that both VL devices were 100% successful in achieving first attempt. However, the CMAC offered an advantage with respect to intubation time (17 ± 5 vs. 25 ± 5 <0.0001) [21]. Yumul et al. [40] in prospective, randomized study compared CMAC to flexible fiberoptic scope in adult patients scheduled for elective cervical spine surgery. They found the CMAC offered an advantage over the flexible fiberoptic scope with respect to the time required to obtain a clear glottic view and successful placement of the tracheal tube in patients requiring manual inline cervical spine immobilization [40]. A study by Rady et al. [41] compared CMAC to flexible fiberoptic scope in adult patients with anticipated difficult airway schedule to elective surgery. The results showed that CMAC compared to fiberoptic scope presented a high success rate on the first attempts, and a significantly shorter intubating time (22 ±3 vs. 63 ± 38 s, respectively).

However, CMAC VL not always showed to be the best option in patients with cervical spine problems. Brück et al. [42] in a prospective randomized study compared CMAC and GlideScope in adult patients scheduled for elective cervical spine surgery with cervical spine disorders and immobilization. To prevent any flexion or extension or any other movement of the head and neck during intubation, the patient neck was immobilized the neck using manual in-line stabilization (holding the sides of the neck and the mastoid process). The results reported that there were no significant differences in postoperative complaints (e.g. sore throat, hoarseness and dysphagia), both devices provided an excellent glottic view, but tracheal intubation was more often successful on the first attempt with the GlideScope. The possibly shorter time to intubate and the greater first-time intubation success with the GlideScope (p=0.002) might reasonably influence choice of airway device in this setting. Sahin et al. [43] in a prospective, observational, controlled study evaluated the movement of the C-spine using fluoroscopy in healthy adult patients undergoing elective surgery during intubation with laryngeal mask airway (LMA) C-Trach CMAC and Macintosh DL. All three intubating devices were consecutively used to see the glottis of each patient, and the same patient served as a control. The LMA C-trach (The LMA, North America Inc. San Diego, CA, USA) is integrated with fiberoptic channels, and a detachable viewer, allows viewing of the larynx and aids endotracheal intubation through a laryngeal mask airway. In this study the LMA C-Trach resulted in less movement of the cervical spine, less trauma to the oropharyngeal structures during tracheal intubation and provided oxygenation and ventilation throughout the intubation procedure. The authors suggested that LMA C-Trach may be considered one of the first-line intubating tools and may be helpful for a less traumatic endotracheal intubation for adult patients with suspected C-spine injury. In another prospective, randomized, single blind study Özkan et al. [44] compared cervical motion during intubation with a CMAC D-blade and an LMA Fastrach (LMA North America Inc., San Diego, CA, USA) using radiological images in adult patients scheduled for elective cervical discectomy. The authors concluded that even though intubation with both a CMAC D-blade and an LMA Fastrach results in cervical

motion within safe ranges, a CMAC D-blade might be preferable for intubating patients with cervical spine disorders as the LMA Fastrach may result in more failed attempts. Jain et al. [45] in a prospective, randomized study in simulated cervical spine injuries (with a cervical collar) of adult patients scheduled for elective surgery, compared CMAC to McCoy laryngoscope regarding their performance. The result showed that CMAC provided a better glottic visualization and lower intubation difficulty than the McCoy laryngoscope of simulated cervical spine patients with a cervical collar in situ.

Emergency department (ED) and outside the operating room

Airway management in the emergency department can be challenging when ED physicians are managing patients with life-threatening conditions, mental stress, a lack of information regarding the patient's past medical history, potential cervical injury with cervical immobilization, and the presence of vomit and/or blood in the oropharyngeal cavity may complicate direct visualization of the airway. Even in experienced hands, along with regular training and practice, successful tracheal intubation sometimes requires additional tools [6]. The use of video laryngoscopy in the in the emergency department (ED) has improved intubation success [46,47]. Sulser et al. [6] in a prospective, randomized study compared CMAC to Macintosh DL in adult patients undergoing emergency rapid sequence intubation in an emergency room sitting. They concluded that CMAC provide a better glottic view, but they also reported that a better visualization did not improve first-attempt intubation success rates in an emergency room. Cavus et al. [18] in a prospective, randomized, multicenter study compared CMAC to A.P. Advance™ (Venner Medical SA, Singapore) and KingVision VL adult patients requiring pre-hospital emergency tracheal intubation. The intubation was performed by emergency physicians founding that all of three VLs provided an adequate view of the larynx; actual intubation was more difficult with the channeled KingVision compared to the CMAC device and A.P. Advance.

Vassiliadis et al. [1] in an observational study (a retrospective analysis of prospectively collected data) compared CMAC to Macintosh DL in patient undergoing endotracheal intubation in emergency room regarding the first pass success rate, airway grade and complications DL blades. The result revealed that CMAC was comparable to DL in regard to glottic view.

However, CMAC was significantly better to DL for intubation success when the glottic view was Cormack and Lehane grade III/IV (P=0.002) and CMAC significantly presented less complication compared to DL in regard to oxygen desaturation (p=0.009) and laryngospasm (p=0.008) [1].

Other investigators [13] have also reported the superiority of the CMAC with a D-blade compared to the McGrath Series 5. However, in patients undergoing emergency intubations in which DL was planned for the first attempt, these investigators did not detect a significant difference between VL and DL using the CMAC device in first-pass intubation success, time required per successful intubation, aspiration pneumonia, or hospital length of stay [48]. Goksu et al. [4] compared the CMAC to the Macintosh for intubation of blunt trauma patients in the ED and found that the CMAC demonstrated improved glottic view and decreased the incidence of esophageal intubations. Combining CMAC VL and bougie with a standardized rapid sequence induction protocol leaded to a high first-attempt intubation success rate when performed by an anesthetist-led helicopter emergency medical service team [49]. Sakles et al. [50] compared CMAC to Macintosh DL in an observational study of a single-center analysis of ED intubations performed during the 5 year in 460 adult patients with a failed initial orotracheal intubation attempt in which the CMAC or DL was used for the second attempt. They found that after a failed first intubation attempt in the ED, regardless of the initial device used for this attempt, emergency physicians were more successful on their second attempt when using the CMAC compared to DL.

In a systematic review and meta-analysis by Hoshijima et al. [51] of prospective randomized trials which compared the CMAC with the Macintosh DL for tracheal intubation in the adult population. Data on success rates, intubation time, glottic visualization and incidence of external laryngeal manipulations (ELM) during tracheal intubation were analyzed. The concluded that the CMAC was superior to the Macintosh DL in terms of glottic visualization, success rates in difficult airway and less incidence of ELM during tracheal intubation. Hwang et al. [52] evaluated the usefulness of CMAC in direct laryngoscopy training residents in the use of DL in the ED, the results showed that using the DL of the CMAC compared to the VL of the CMAC demonstrated a significant better first pass success and lower rates of multiple attempts and complication. Making CMAC a useful tool for training residents in the direct laryngoscopy while ensuring patient safety in the emergency department. Eisenberg et al. [53] compared CMAC to Mac DL on success rate and complication rate of intubations performed in a pediatric emergency department; it was found no difference in regard to first-pass intubation success rate, complication rate, or rate of successful intubation by ED providers for children undergoing intubation in a pediatric ED. However, video-assisted laryngoscopy allows for safe, supervised intubation attempts by trainees in a patient population with potentially challenging airways and therefore its use as first-line equipment for pediatric intubations is likely to continue to grow.

PEDIATRIC PATIENTS

When the CMAC was used to perform tracheal intubation in infants in the lateral position, it reduced the time required to perform the intubation when compared to the Miller laryngoscope, suggesting it may be more useful device when intubating the trachea of infants in the lateral position [54]. Sixty children weighing 3-15 kg with normal airway requiring tracheal intubation with a CMAC Miller blade were randomly divided into either a non-styletted or styletted tracheal tube group. Styletted tracheal tube significantly reduces time for intubation compared to the non-styletted ETT [55]. First-pass success rates during intubation of infants in the emergency department have been shown to be low. Video laryngoscopy is being increasingly used during advanced airway management in the emergency department. In a case report published by Miller et al., the CMAC with Macintosh size 0 (curved) blades was used in two infants with apnea secondary to respiratory syncytial virus bronchiolitis in the ED. CMAC was found to provide a favorable glottic view and improved maneuverability [56].

In a case report by Shukeri [57] the CMAC was used to intubate a 3 year old child with Goldenhar syndrome with anticipated difficult intubation (micrognathia, mandibular hypoplasia, limited mouth opening, reduced neck mobility and Cormack-Lehane III-IV). The first attempt was made with Miller blade 1, the second with Macintosh blade 2, then the senior anesthesiologist used the Miller blade 1 for the third attempt and failed; trying once more (fourth attempt) with the same blade plus concurrent external laryngeal manipulation and more shoulder elevation and a bougie was inserted towards the location of the glottic opening, obtaining a successful intubation. It is worth noting that the relatively bulky handle of the device may interfere with the intubation process by abutting the patient's chest, thus preventing full insertion of the blade [57]. In another case report published by Gupta and Gupta, of an unanticipated difficult intubation in a 7 day old boy with a thick anterior laryngeal web who had several failed intubations attempts with DL Miller and Macintosh blades. Then CMAC Miller blade 1 was used, improving the glottic view (from Cormack and Lehane grade IIIa to I) and facilitated a successful intubation [58]. However, in a prospective, randomized study in children (1-6 years) with normal airway scheduled for elective surgery, Singh et al. [59] compared CMAC (Mac blade size 2) to Macintosh DL (Mac blade size 2) and the Truview PCD (blade 2) (PSC: Picture Capture Device). Truview PCD as compared with C-MAC and Macintosh DL provided a significant better glottic view (POGO scores (95 ± 12.9/82 ± 25/85 ± 17; $p<0.01$, respectively)) and a shorter intubation time in pediatric patients. It was noted that CMAC provides a good resolution and can be used as a teaching tool [59,60]. Moussa et al. [61] published a prospective, randomized, controlled study in NICU to assess whether the CMAC VL (with blade size 0 or 1) was superior to Rush® DL (with Miller blade size 00, 0 or 1) (Rusch®, Teleflex Medical, Markham, Canada) in acquiring skill in neonatal endotracheal intubation and, once acquired with the VL, whether the skill is transferable to the CL. The author concluded that when learning how to perform tracheal intubation in pediatric patients, the first attempt success rate was improved with the CMAC when using blade size 0 or 1 compared to Rusch laryngoscope blade. The CMAC showed to be a promising tool for teaching neonatal ETI and possibly plays an important role in solving the problem of technical skill acquisition of pediatric residents while insuring patient safety [61].

Sethi [62] published a case report where CMAC D-blade was used in a 14 years old child with Treacher Collins syndrome with a difficult airway who underwent auricular reconstruction surgery. The CMAC D-blade provided a glottic view (Cormack-Lehane grade I) that allowed a successful tracheal intubation on the first attempt without complication. Raimann et al. [63] in a prospective study compared the intubation conditions obtained when using the CMAC with Miller blades sizes 0 and 1 for standard DL and indirect laryngoscopy (both view obtained with CMAC) in children weighing less than 10 kg. The results revealed that the use of indirect laryngoscopy (CMAC monitor view) provided a significantly better glottic view ($P<0.05$). Patil et al. [5] compared CMAC to conventional DL with a Macintosh laryngoscope blade in pediatric patients undergoing tonsillectomy surgery using a nasotracheal intubation. CMAC showed to be better in terms of glottis visualization, intubation time and need for additional maneuvers.

In addition, CMAC has been used in pediatric airway obstruction due to foreign bodies. Punnoose et al. [64] reported two cases where CMAC was used to successfully remove the laryngeal foreign body from the airway of two children (1 and 2 years old), while both the anesthesia provider and the otolaryngologist was having a continuous visualization of the airway.

SIMULATION LAB

CMAC has been used for teaching tracheal intubation in different scenarios to medical students and residents using manikins [22]. In a study comparing DL to VL, trainees participants performed DL using Miller and Macintosh laryngoscopes and VL using CMAC and GlideScope devices on a pediatric manikin. Use of the CMAC was associated with shorter procedural times and higher intubation success rate compared with indirect VL with the GlideScope, in the hands of both experienced and inexperienced users [11]. In another study, the CMAC device and the Bonfils enabled better visualization of the glottic opening when compared with the Macintosh laryngoscope in both normal and difficult airway situations 65]. CMAC has been used as a teaching tool in manikins designed with cervical spine problems and suggest that it may be preferable to direct laryngoscopes in those clinical situations [45,66,67]. In other

studies: Cierniak et al. [68] found that students found the CMAC was easier to operate than the Vivasight™ (ETView Ltd., Misgav, Israel) VL (The endotracheal tube has incorporated a high-resolution imaging camera and a light source in its tip, the view of the patient's airway is seen on the screen of the VivaSight™ monitor. A randomized, crossover study [14] compared McGrath MAC, CMAC, to Macintosh DL operated by Medical Students who performed sequential intubations on the manikin in two simulated settings that included a normal airway and a difficult airway (tongue edema). A blade size of 3 was used for all devices. The authors found that in the difficult airway, the intubation times were similar among the three devices. Nevertheless, in the normal airway the CMAC and McGrath MAC resulted in a similar decrease in intubation time compared to the Macintosh blade. The CMAC and McGrath MAC showed significant improvements in the success rate, glottic view and difficulty of use compared to the Macintosh blade in both the normal and difficult airways.

However, in another manikin-study by Schuerner et al. [69] compared hands-off time and intubation success of DL to CMAC VL. All participants (who none of them had any previous experience with VL) performed endotracheal intubation using DL Macintosh blade size 3 and CMAC blade size 3 in a random order during ongoing chest compressions. The result demonstrated that CMAC might not be beneficial compared to conventional DL in easily accessible airways under CPR conditions in experienced hands (hands-off time (s) using DL: 1.9 ± 2.1 vs. CMAC: 3.0 ± 2.7, p-value=0.048); the benefits of VLs are of course more distinct in overcoming difficult airways, as it converts a potential "blind intubation" into an intubation under visual control.

Ömür et al. [70] in a prospective randomized crossover study compared five intubation methods for use with standardized airways, including using 4 different stylets (hockey-stick; D-blade type, CoPilot VL rigid, and gum elastic bougie) or no stylet in a manikin simulating difficult intubation with the CMAC D-blade VL. The investigator reported that the CMAC D-blade is specially designed for use in difficult airway interventions. It provided better imaging, but it can be difficult to direct the endotracheal tube within the mouth, thus it may be necessary to use a stylet of an appropriate shape. This study showed that the use of all stylets provided quicker intubation, allowed easier passage of the ETT through the vocal cords and decreased the total intubation duration in manikins compared to no stylet use. The duration to pass the vocal cords significantly differed among all groups ($p<0.001$). The total intubation duration was shortest when using D-blade stylet, CoPilot stylet and hockey stick stylet. Although no difference was observed between stylet groups, a significant difference was found between each of these three and no stylet and gum elastic bougie ($p<0.05$ and $p<0.001$, respectively).

There are also other studies comparing conventional CMAC with other airway devices in simulated cervical spine injury using airway manikins. For example, Jain et al. [67] compared four airway devices and found the overall performance of the conventional CMAC proved to be superior when compared with the CMAC D-blade, Macintosh blade and the McCoy blade when the intubations were performed by anesthesia residents. In a randomized crossover manikin study by Yildirim et al. [71] comparing the CMAC D-blade, to Macintosh blade and the McCoy in intubation performed by pre-hospital emergency medical technicians with at least 2 years' active service in ambulances on manikins' models with immobilized cervical spines. All participating technicians completed intubations in three scenarios, a normal airway model, a rigid cervical collar model and a manual in-line cervical stabilization model. All blade used were size 3. In this study was found CMAC D-blade and the McCoy success rates were significantly higher than the DL rates in all scenario models ($p<0.05$) and that the CMAC D-blade intubation duration was significantly shorter ($p<0.05$) when compared with DL and McCoy in all models. Suggesting that both VL may provide an easier, faster intubation by pre-hospital emergency health care workers in patients with immobilized cervical spines. Hunter et al. 16] compared the time taken to intubate the trachea of a manikin by novice medical students immediately after training, and later after 1 month, with no intervening practice using the Macintosh, Venner™ A.P. Advance™, CMAC D-Blade and Airtraq® with wireless video-viewer. The results showed no significant difference in intubation time using the video laryngoscopes compared with the DL Macintosh immediately after the training. However, one month later, the intubation time was longer using the CMAC and A.P. Advance compared with the DL Macintosh. The skill acquisition after a brief period of learning and practice was equal for each laryngoscope; however performance levels differed after 1 month without practice. Investigator suggests that reliable, consistent and regular practice performance at laryngoscopy is desirable; for the devices tested.

CONCLUSION

The current scientific evidence suggests that the CMAC VLs device may offer advantages over standard DL with a Macintosh blade for the intubation of patients with a known difficult airway and in situations requiring cervical immobilization. In patients with normal airway anatomy, there is no convincing scientific evidence. CMAC and other VLs are getting recognition as a helpful instrument in providing emergency airway management and in resolving medical emergencies as such as airway foreign body removal and for difficult NGT placement in properly trained physicians and emergency personnel.

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