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# Effectiveness of C-MAC video-stylet versus C-MAC D-blade video-laryngoscope for tracheal intubation in patients with predicted difficult airway: Randomized comparative study

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**ABSTRACT**

**Background:** This prospective study was done on patients with suspected difficult airway to compare between C-MAC video-stylet (VS) and D-blade video-laryngoscope for tracheal intubation.
**Patients and methodology:** Randomization was done on 160 adult patients with anticipated difficulty in intubation for different causes to divide them into two equal groups (VS group and D group). Patients in each group were divided into five categories according to the cause of anticipated intubation difficulty. Duration of intubation, number of attempts, and success intubation rate were recorded. Hemodynamics parameters were measured before intubation as baseline, then after intubation at 1 and 5 min.
**Results:** In VS group, intubation time ranged between 23 and 166 s with mean of 53.2 ± 24.19 s and in D group it ranged between 30 and 279 s with mean of 65.5 ± 40.63 s (*P*-value 0.021). This shorter intubation time was not constant in different patient's categories. The first attempt intubation was successfully done in 68 patients (85%) in VS group versus 61 patients (76.3%) in D group. Hemodynamically, HR and MABP showed significant increase in D group more than in VS group at 1 and 5 min after intubation (*P*-value = 0.001).
**Conclusion:** Both devices are helpful when there is a risk of difficult intubation. C-MAC VS is a better choice in cases of limited mouth opening and obesity, but in cases of limited cervical motility, the use of C-MAC D-blade is a better choice with a faster intubation time.

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C-MAC video - stylet; C-MAC D-blade; difficult airway; intubation time

## 1. Introduction

Difficult tracheal intubation is considered the most important cause for morbidity and mortality during induction of anesthesia [1,2]. About 25% of deaths correlated to anesthesia can be attributed to a compromised airway [3].

Recently, video laryngoscopy (VL) has been widely used in cases of difficult intubation as it has shown to produce better visualization of the anatomical airway structures [4,5]. C-MAC VL is introduced by Karl Storz, Tuttlingen in Germany in 1999 [6,7]. It has many merits over the traditional laryngoscope. The advanced optical system and its light source (high intensity light-emitting diodes) led to a clear view of the vocal cord and enabled the operator to overpass the tip of laryngoscope blade to reach into the vallecula under vision [8,9]. C-MAC VL can fit Macintosh blade sizes 2, 3, 4 in addition to other models as Miller sizes 0, 1 and the C-MAC D-Blade [10–12]. The D-blade is highly angulated. Its distal end has greater curvature and faces upward to get the shape of half-moon and these features gave a better view of the glottis and required less cervical spine motion than the conventional one and so it can be used as an alternative blade in difficult airway conditions [13,14].

Karl Storz, Tuttlingen in Germany recently introduced a new addition to the C-MAC system, which is C-MAC Video Stylet (VS); it possesses the advantages of both rigid and flexible intubation endoscopes [15]. It is composed of rigid unchanneled metal stylet with 4 cm flexible dynamic tip at which there is light source and mini size video camera. It is connected to the monitor screen to display the images on it, giving a direct view of vocal cord and upper tracheal rings and so it helps in cases of anticipated difficult intubation [16]. It can accommodate size 6.0 endotracheal tube or greater. Tracheal tube is loaded on the stylet and a tube holder is used to keep it in its place, facilitating the advancement of the VS and the tracheal tube as one unit. Then they automatically entered to the glottis as single unit once an adequate view is obtained under direct vision.

Varieties in the new video-assisted intubating devices raised the following question: is there a difference between them in different intubating conditions? In addition, what is the optimal one for each condition?

The present study was planned to compare between using C-MAC VS versus C-MAC D-blade video-laryngoscopy in different cases of anticipated difficult airway to determine the best-suited device for each

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situation and the all-over practicality of each device. The intubation time was used as a primary outcome to assess the ease of using each device. The secondary aims included hemodynamic measurement during intubation and detection of postoperative complication related to each device.

## 2. Patients and methods

After obtaining the approval of Alexandria University Ethical Committee (IRB No: 00012098) and registration at Clinical Trial.gov: NCT04759300, this prospective, randomized, single blinded study was conducted from January 2022 to May 2022 on 160 adult patients of ASA I&II of either sex aged between 18 and 65 years undergoing general elective surgery. Written informed consents were taken from all participants.

Patients participating in the study were categorized into five categories according to the anticipated cause of difficult intubation. First category was patients with limited mouth opening (inter-incisor distance <3 cm); patients in second category were with BMI ≥35 kg/m$^2$; third category included patients with limited neck movement (neck extension <80°from neck flexion); fourth category was patients with Mallampati score III or IV. Patients with other cause of anticipated difficult intubation for example thyromental distance <6 cm, any previous history of difficulty with mask ventilation or difficult intubation were all included in the fifth category.

Patients with significant medical diseases cardiac, respiratory, hepatic, or renal; pregnant patients; patients with increased risk of pulmonary aspiration; patients with unstable cervical spine injury or presented for an emergency surgical procedure, etc. were excluded from the study.

Using specialized computer randomization software, participating patients were randomly split into two equal groups so that each group would contain equal number of patients from the same category. Intubation in VS group was done with C-MAC VS, while in D group intubation was done with the C-MAC VL D-blade. Randomization cards were used and put in concealed envelopes to document the result of randomization. All participants were blinded to the intubation technique used. The anesthesiologist and investigators remained blinded to the randomization process until the randomization card was opened after the patient entered the operating room. Intubation was performed by an expert anesthesiologist with minimum 5 years of experience in using video-laryngoscope and the rigid/semi-rigid intubation stylets.

All patients were positioned in sniffing supine position except obese patients and patients with limited cervical spine motion. Ramping position was used for patients with BMI ≥35 by placing multiple folded towels under upper half of the patient's body, neck and head till reaching the desired horizontal alignment of the external auditory meatus and the sternal notch. In-line axial stabilization was done manually with precaution for patients with limited cervical spine motion to prevent any rotational movement or flexion/extension of the head and neck.

All patients were connected to multichannel monitoring system for electrocardiography, non-invasive blood pressure, pulse oximeter, peripheral nerve stimulator and capnography.

Standard anesthesia plan was applied for both groups. Pre-oxygenation with 100% oxygen at 6 L/min for 3 min; then, induction was done using intravenous 1–1.5 µg/kg fentanyl, propofol at a dose of 2–2.5 mg/kg and for muscle relaxation rocuronium bromide 0.6 mg/kg was used.

Patients in D group were intubated using C-MAC D-blade according to the manufacturer recommendations [12,13]. Introduction of the blade into the mouth was done from the center of the oral cavity over the tongue. While looking at the display screen, the tip of the blade was introduced further to reach the best view of the glottic by positioning the tip of blade in the vallecula. When the epiglottis and the vocal cords were visualized on the monitor, the tube was advanced into the glottic inlet then the blade was withdrawn slowly.

In VS group, the anesthesiologist performed a jaw thrust with his left hand to expose the laryngeal inlet. VS preloaded with size 7.0 tracheal tube, grasped with the right hand was introduced into the center of the mouth parallel to the sagittal plane. Then the stylet was advanced slowly under vision along the palate till the uvula. The anesthesiologist then manipulated the tip of the video stylet till the opening of the glottis appeared on the monitor screen. Advancement was done until the distal tip became above the vocal cords and getting a full image of the vocal cords. Using the left hand, tracheal tube was passed carefully into the trachea till the cuff was seen crossed the vocal cord. After confirming the tracheal tube place by capnograph, the VS was removed slowly.

After confirmation of successful intubation, all patients were placed on mechanical ventilation with maintenance of end-tidal $CO_2$ between 36 and 40 mmHg. Maintenance of anesthesia was done with isoflurane 1.5–2% in 100% oxygen. Incremental doses of rocuronium 0.15 mg/kg guided by the nerve stimulator was used. At the end of the surgery, reversal of residual muscle relaxation was done with neostigmine 0.04 mg/kg with atropine 0.01 mg/kg. Extubating was done after fulfilling its criteria, and after that the patient was transferred to the post-anesthesia care unit.

An intubation attempt was considered unsuccessful if the VS or D-blades were withdrawn from the mouth

without completing the intubation. Only three attempts were allowed and after that failed intubation using that device was documented, and other alternative methods for airway management were applied.

Intubation time was measured in seconds from insertion of VS or D-blade into the mouth till confirmation of tracheal tube placement by capnography. Proper tracheal tube position was reconfirmed by auscultation for equality of air entry bilaterally.

Intubation time, number of intubation attempts and success rate were recorded. For hemodynamics, baseline reading was taken before intubation, and then measurement was repeated 1- and 5-min after intubation.

## 3. Statistical analysis

Sample size was calculated based on a previous study and by using Med Calc statistical software. Area under ROC curve was assumed to be 0.80, an alpha of 0.05 and power of study 90.0%. A typical advice is to reject the null hypothesis H0 if the corresponding *p*-value smaller than 0.05. A minimum sample size required was 160 patients for this study, 80 patients in each group.

Data were fed to the computer using IBM ***SPSS software package version 24.0.***

Shapiro–Wilk test was used to test of normality of data; the data was parametric data, and the Shapiro–Wilk for different data ranged from 0.893 to 0.975 with *p* value <0.05.

Qualitative data were described using number and percent. Comparison between different groups regarding categorical variables was tested using Chi-square test.

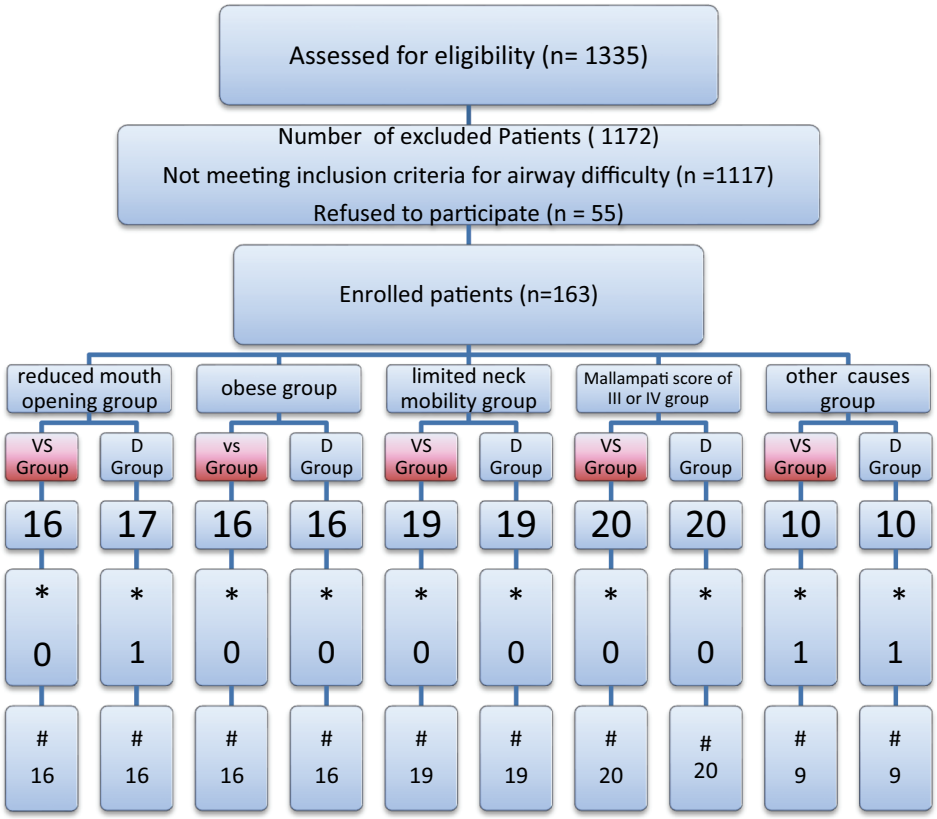
Quantitative data were described using mean and standard deviation for normally distributed data while abnormally distributed data was expressed using median, minimum and maximum.

For normally distributed data, comparison between two independent population was done using independent t-test; while more than two population were analyzed, F-test (ANOVA) was to be used.

Significance test results are quoted as two-tailed probabilities. Significance of the obtained results was judged at the 5% level.

## 4. Results

From January 2022 to May 2022, about 1335 patients prepared for elective surgeries under general anesthesia were initially assessed to detect any predictor for difficult intubation. A total of 1172 participants did not meet the inclusion criteria or




*Number of cases with discontinued intervention
# Number of analyses cases

**Figure 1.** Flow chart of the study.

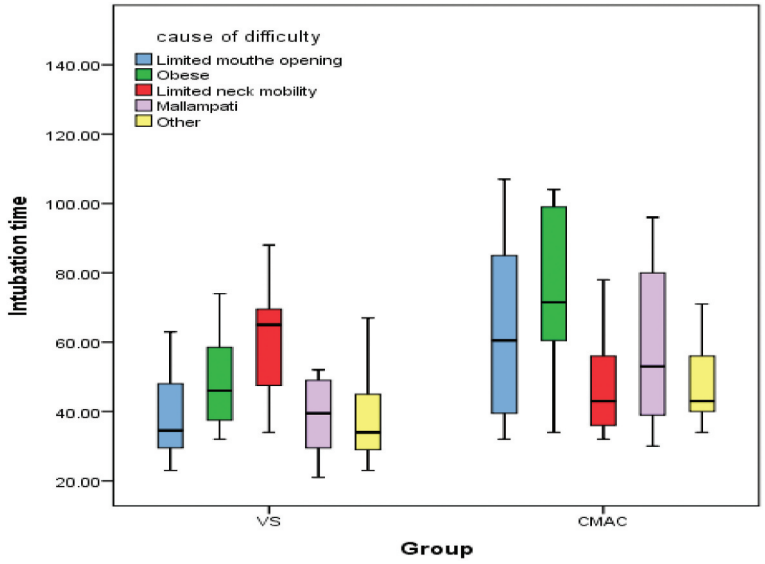



**Figure 2.** Intubation time in each difficulty cause in both studied groups.

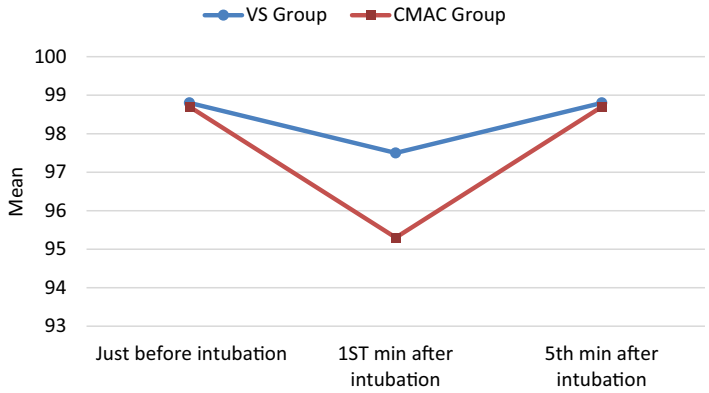



**Figure 3.** Oxygen saturation in both groups.

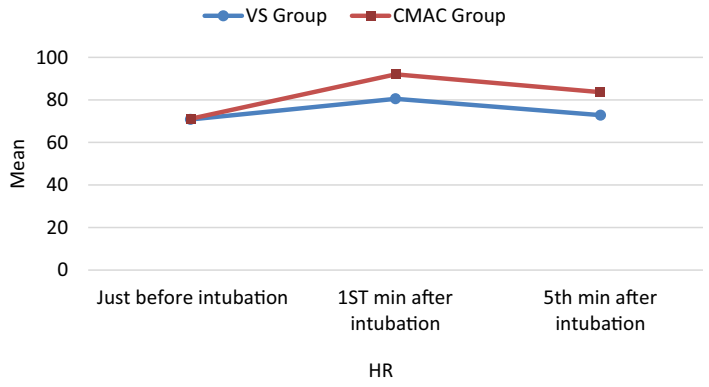



**Figure 4.** Heart rate changes in both groups.

refused to share in the study; only 163 patients were allocated and statistically analyzed as shown in the flow chart (Figure 1). Three of them did not complete the intervention with the selected device.

The patients' baseline data are shown in Table 1. Both groups were comparable with no statistical difference regarding the age, gender and body mass index.

First attempt intubation was successfully done in 68 patients (85%) in VS group versus 61 patients in D group (76.3%), as shown in Table 2. 97.5% of the cases in VS group needed no additional devices to help

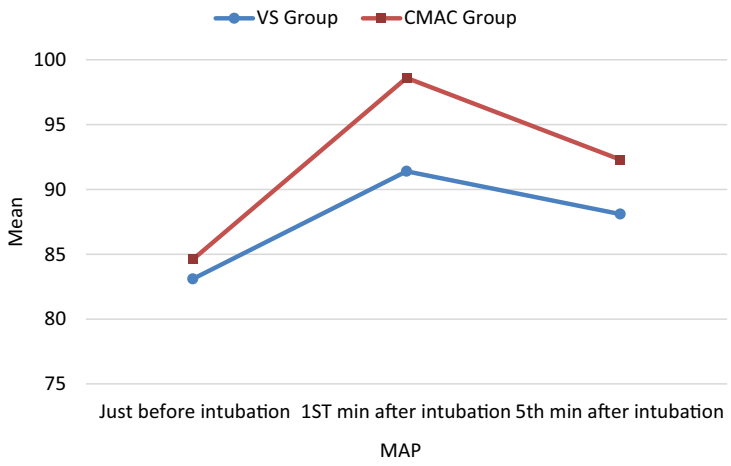



**Figure 5.** Mean Arterial Blood Pressure (MABP) changes in both groups.

**Table 1.** Characteristics of the participants in both groups.

| Personal data | VS Group "n=80" | | D Group "n=80" | | *P*-value |
|---|---|---|---|---|---|
| Age in years | | | | | |
| Range | 19–64 | | 19–64 | | 0.1 N.S. |
| Mean ± SD | 44.7±12.7 | | 41.8±12.5 | | |
| Sex | No | % | No | % | 0.3 N.S. |
| Male | 40 | 50 | 36 | 45 | |
| Female | 40 | 50 | 44 | 55 | |
| BMI | | | | | |
| Range | 17–43 | | 18–43 | | 0.2 N.S. |
| Mean ± SD | 27.6±6.8 | | 28.4±6.6 | | |

Data were expressed in terms of mean ±SD, range and percentage.
N.S.: not significant.

**Table 2.** Intubation conditions in both groups.

| | VS Group "n=80" | | D Group "n=80" | | *P*-value |
|---|---|---|---|---|---|
| Number of intubation attempts | **No** | **%** | **No** | **%** | 0.2 |
| One attempt | 68 | 85.0 | 61 | 76.3 | |
| Two attempts | 11 | 13.8 | 14 | 17.5 | |
| Three attempts | 1 | 1.3 | 5 | 6.2 | |
| Assisting device needed | | | | | 0.001* |
| No | 78 | 97.5 | 19 | 23.8 | |
| Stylet | 0 | 0 | 54 | 67.5 | |
| Bougie | 0 | 0 | 7 | 8.75 | |
| Oral airway | 2 | 2.5 | 0 | 0 | |
| Technician assistance needed | 10 | 12.0 | 29 | 36.3 | 0.001* |

Data were expressed in terms of mean ±SD, range, and percentage.
**P*-value significant at ≤0.05.

in intubation; only two cases needed an oral airway to keep the mouth opened. On the other hand, 76% of the cases needed some guidance to the tracheal tube in the form of stylet or Bougie.

The intubation time for all the patients in VS group ranged between 23 and 166 s with mean ± SD of 53.2 ± 24.2 s and 30–279 s with mean ± SD of 65.5 ± 40.6 s in D group. Statistically significant decrease in VS group compared to D group was detected with *P*-value = 0.021.

By studying the effect of both devices on the intubation time in different causes of difficulty in intubation as shown in Table 3 and Figure 2 and Figure 3, it was found that using VS in cases of limited mouth opening and obese patients took significant less time to intubate in comparison to D-blade. On the other hand, in cases of limited neck mobility, intubation time was significantly shorter in D group. No difference was found between the two devices regarding the intubation time with the other two categories of difficult airway intubation.

To investigate the most significant factor that affects the intubation time, analysis of the multiple logistic regressions of different risk factors was done. It showed that the only factor affecting the intubation time was the device used for intubation (VS or C-MAC), in different difficult intubating conditions, as shown in Table 4.

Regarding $SpO_2$, there was statistical descend in $SpO_2$ in C- MAC D group more than in VS group after 1 min from intubation but by the 5th min no difference was

**Table 3.** Intubation time in both groups in different causes of difficult airway.

| Intubation time | VS Group "n=80" | D Group "n=80" | *P*-value |
|---|---|---|---|
| Intubation time for all the patients in sec. | | | 0.021* |
| Range | 23–166 | 30–279 | |
| Mean ± SD | 53.2±24.2 | 65.5±40.6 | |
| For Limited mouth opening | | | 0.001* |
| Range | 23.0–63.0 | 32.0–178.0 | |
| Mean± SD | 38.6±12.2 | 73.3±43.5 | |
| For Obese | | | 0.0023* |
| Range | 32.0–98.0 | 34.0–279.0 | |
| Mean± SD | 50.9±17.5 | 92.1±62.4 | |
| For Limited neck mobility | | | 0.0139* |
| Range | 34.0–145.0 | 32.0–89.0 | |
| Mean± SD | 63.8±24.9 | 48.7±16.3 | |
| For Mallampati ≥III | | | 0.2 N.S. |
| Range | 38.0–166.0* | 30.0–153.0 | |
| Mean± SD | 62.4±30.4 | 61.4±30.1 | |
| For Other | | | 0.1 N.S. |
| Range | 23.0–67.0 | 34.0–71.0 | |
| Mean± SD | 40.3±15.3 | 49.1±13.1 | |

Values are presented as mean ± SD and range.
*Significantly different compared to other group ($P \leq 0.05$).

**Table 4.** Multiple regression analysis of different risk factors in relation to intubation time.

| Model | Un-standardized coefficients B | Un-standardized coefficients Std. Error | Standardized coefficients Beta | t | Sig. |
|---|---|---|---|---|---|
| Constant | 31.9 | 20.7 | | 1.5 | 0.1 |
| Device used | 15.8 | 5.4 | 0.2 | 2.9 | **0.004*** |
| Cause of difficulty | 3.5 | 2.1 | 0.1* | 1.7 | 0.1 |
| Age | 0.3 | 0.2 | 0.1 | 1.6 | 0.1 |
| Sex | 7.2 | 5.5 | 0.1 | 1.3 | 0.2 |
| BMI | 0.3 | 0.4 | 0.1 | 0.8 | 0.4 |

Dependent variable: intubation time.
F-test (ANOVA) was used.
**P*-value significant at ≤0.05

**Table 5.** Complications assessment in both groups.

| Complication | VS Group "n=80" No | VS Group "n=80" % | D Group "n=80" No | D Group "n=80" % | *P*-value |
|---|---|---|---|---|---|
| Dental trauma | 2 | 2.5 | 3 | 3.8 | 0.6 N.S. |
| Hematoma | 1 | 1.3 | 4 | 5 | 0.1N.S. |
| Sore throat | 3 | 3.8 | 5 | 6.3 | 0.1N.S. |

found between the two groups. Both HR and MAP increased significantly in D group more than in VS group at 1 and 5 min after intubation with *P* value = 0.001. In spite of this significant difference between both groups in the hemodynamics, all the changes were within the acceptable levels at all measuring times as shown in Figure 4 and Figure 5.

Assessment of the complications resulting from the use of both devices showed no significant difference between the two groups, as shown in Table 5.

Values are presented number (percentage).

## 5. Discussion

The results of this research study revealed that mean intubation time for the entire patient in VS group was short than in D group by more than 12 s, which is a statistically significant time difference. When using the VS, the shorter intubation time was seen clearly in cases of limited mouth opening and in morbid obesity, but in cases with limited neck mobility the use of the C-MAC D-blade led to a significantly faster intubation. No superiority of one device over the other regarding intubation time was noted in other causes of difficulty in intubation as patients with Mallampati ≥III. This finding is very important as it might affect the decision of the anesthesiologist in choosing the intubating tool. The variation in the intubation time when using each device on patients with different predictors of airway difficulty might be due to the difference in the design of each device. The relatively thin shaft of VS and its mobile tip with a high-resolution camera at the distal end generating a perfectly clear image made it easy to use in obese patients and patients with limited mouth opening [16].

On the other hand, D-blade, when used, makes the pharyngeal, laryngeal axes lie in the same plane with minimal manipulation, and the tongue remains in the midline with no need to be shifted to the right side as with conventional laryngoscope. These changes are adequate to view the glottis and give a great benefit in cases with limited neck extension [13, 17, 18].

Jain et al. [18] investigated the role of D-blade in limited cervical motion in a study prepared to compare the conventional C-MAC D-blade with direct laryngoscopes in simulated cervical spine injury in a manikin. They found statistically significant improvement in the laryngoscopic view when using D-blade in comparison with the direct laryngoscopes.

The results of this work were in agreement with James Pius et al. [1] who compared in their study the C-MAC VS versus C-MAC Macintosh video laryngoscope in a prospective randomized manikin study. The study stated that the median intubation time to intubation on a simulated difficult airway was shorter with the C-MAC VS (17 s) compared to C-MAC Macintosh VL (23 s) with $P$ value = 0.031.

Darshan [19] performed a recent prospective randomized controlled study on 60 adult patients of ASA II & I ready for elective surgeries under general anesthesia and were randomized equally into group C-MAC and group video-stylet (VS) with cervical collar applied before induction. Pre-anesthesia evaluation (PAE) and airway difficulty were assessed. Time taken for intubation, success rate, and intubation difficulty scale (IDS) were parameters observed. The mean time for intubation in Group C-MAC was 25 s and in Group VS it was 22 s. Eight patients needed a second intubation attempt in group C-MAC compared to 3 in VS group; the difference was not statistically significant ($P = 0.2$). IDS between the two groups suggested statistically superior results with VS group than C-MAC group.

Previous research studies were applied on manikin to compare between the Bonfils rigid endoscope versus C-MAC VL. One of these studies was done by Kaplan et al. [20], which demonstrated a total intubation time of 14 s with the use of Bonfils versus 15 s with C-MAC VL in normal intubating conditions.

Analysis of the multiple logistic regression of different risk factors that may have effect on the duration of intubation time showed that the only factor affecting the intubation time was the device used (VS or C-MAC) in different airway scenario management. However, demographic characteristics (age, sex, BMI) had shown insignificant effect on intubation time in comparison with type of device used.

In this study, the need for an assistant during intubation was also investigated and the results revealed that a technician was needed with the C-MAC D-blade in 36% of the cases to manipulate the larynx or to pull on the stylet or the Bogy. For about 76% of the cases in this group, the anesthetist was using both his hands holding the laryngoscope with one and pushing the tube with the other. On the other hand, only 12% of the cases in the other group needed a technician assistant, as no stylet was used and also when using the C-MAC-VS, only one hand was required for manipulation of the device rendering the anesthetist with one free hand to push the tube or any manipulation needed.

In the current research, statistically significant increase in HR and MAP was detected 1- and 5-min post-intubation in D group more than in VS group. This increase may be as a result of a higher sympathetic stimulation from the manipulation of vocal cord and the pharynx by the D-blade in comparison to a gentler manipulation by the CMAC-VS.

The complications detected in the study, dental trauma, hematoma or sore throat, were mild and presented in a few numbers of cases in both groups that had no clinical significance.

Due to the big difference in the patient's airway anatomy that led to different causes of anticipated difficulty in intubation, it was left up to the anesthetist to assess the need to use the stylet or the Bougie during intubation in spite of it being a routine practice to use the stylet during intubation with the D-blade. This was considered as a limitation to the study.

Further studies with larger sample size comparing different intubating devices in deferent intubating conditions are needed to determine the best device suited to be used for each cause of difficult intubation.

## 6. Conclusions

When compared with C-MAC D-blade, the C-MAC VS emerged as a better tool in managing difficult airway intubation in terms of intubation time, number of attempts, and ease of intubation. That conclusion does not apply to all causes of difficult intubation.

The C-MAC VS is a better choice in cases of limited mouth opening and obesity; but in cases of limited cervical motion, the use of C-MAC D-blade leads to faster intubation. It was concluded from the results of this study that every intubation condition has an intubation device that is optimal for it. To optimize the intubation procedure, we should use an intubation device that is most suitable for it.

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## Disclosure statement

No potential conflict of interest was reported by the authors.

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## Author contributions

All authors are responsible for the whole manuscript; they revised and approved the final manuscript.

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