Doi: 10.5152/TJAR.2021.21863

Original Article
Airway Management

Turkish Journal of Anaesthesiology & Reanimation

Comparison of Different Types of Stylets with No-Stylet Technique for Intubation with C-MAC D-Blade® Videolaryngoscope in Simulated Difficult Airway: A Prospective Randomised Study

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Cite this article as: Goel R, Anand LK, Singh M, Jindal S, Rani M, Kaur A. Comparison of Different Types of Stylets with No-Stylet Technique for Intubation with C-MAC D-Blade® Videolaryngoscope in Simulated Difficult Airway: A Prospective Randomised Study. *Turk J Anaesthesiol Reanim.* 2021;49(6):445-452.

Abstract

Objective: The angulated C-MAC D-Blade videolaryngoscope (VL) is designed for difficult intubation and may not be compatible with standard PVC endotracheal tubes (ETTs). This study was planned to compare efficacy of C-MAC, D-Blade VL using ETT with three different stylets versus no-stylet in patients undergoing tracheal intubation with simulated difficult airway.

Methods: After obtaining written informed consent and IEC approval, a total of 144 adult patients were allocated to four groups of 36 each using no-stylet or different types of stylets. The four groups were as follows: Group NS: no-stylet; Group CS: C-MAC stylet; Group DS: D-Blade-type stylet; Group HS: hockey-stick shaped stylet. A rigid appropriate-sized Philadelphia cervical collar was placed around the neck to simulate difficult airway, and C-MAC D-Blade VL was used for intubation. The duration of each intubation stage and attempts were evaluated. Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) version 22.0 (IBM SPSS Corp.; Armonk, NY, USA), and appropriate tests for different variables were applied. Appropriately, Student's t test, Chi-square test, Mann–Whitney U test, and one-way ANOVA test were applied.

Results: Similar Cormack Lehane grade glottic view was observed in all groups. The number of attempts and duration of intubation were significantly greater using NS group than for other groups. Additional laryngeal manipulation was required in all cases in Group NS, compared to one, zero, and two cases in Groups CS, DS, and HS, respectively ($P < .001$).

Conclusion: Use of Hockey stick shaped stylet, D-Blade-shaped stylet, and C-MAC stylet decreased the total intubation duration in patients with simulated difficult airway.

Keywords: Airway management, insertion ease, intubation, videolaryngoscope, stylets

Introduction

Videolaryngoscopes (VLs) facilitate tracheal intubation by improving the view of larynx, thus reduce the number of failed intubations.[1] For anticipated difficult airway management, VL is a life-saving and effective method.[2,3] The C-MAC D-Blade® VL (Karl Storz, Tuttlingen, Germany) is a laryngoscopic device that is specifically designed for the management of difficult airway. The C-MAC D-Blade has greater curvature and a distally placed camera, designed to "see around the corner." This increases the ease of laryngoscopy when conventional laryngoscopy is difficult.[4,5] The angle of vision of C-MAC VL Macintosh blades numbered 3 and 4 is 72° and 60°, respectively. The C-MAC D-Blade VL has greater angle of vision, i.e., 80°, and it is due to embedded optic lens.[6] The compatibility with anatomy of oropharynx is possible due to elliptic and narrow shape of the VL blade, and further a wider view of interior of the mouth is obtained.

The greater angulation of the C-MAC D-Blade is not compatible with lesser angulation of routinely standard endotracheal tubes (ETTs) used. C-MAC D-Blade VL provides better image of laryngeal view without need for

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Received: 08.10.2021 Accepted: 27.02.2021
Available Online Date: December 17, 2021

aligning three airway axes, especially in difficult airway conditions. This makes difficult to align the ETT along the curve of blade within the oropharynx for successful tracheal intubation, and thereby increases the duration of tracheal intubation significantly.[2] Although the current literature emphasises the superiority of this device in normal and difficult intubations as compared to other VLs, yet stylet is necessarily required for insertion of ETT. The shape of the stylet is very important for smooth atraumatic intubation. Thus, the stylet is to be prepared in appropriate way before intubation.[5]

To resolve this problem, it may be necessary to use a stylet of an appropriate shape within the intubation tube with the C-MAC D-Blade VL. Manikin studies have confirmed that appropriate use of stylet allowed an easier, quick intubation for routine and difficult endotracheal intubation.[7–10]

However, on searching the literature at internet, very few studies are available on C-MAC D-Blade VL and usefulness of the stylets for airway management especially in patients with restricted neck mobility. Hence, the present study was planned to compare the success rate of intubation using C-MAC D-blade VL using ETT with three different stylets versus no-stylet in patients undergoing tracheal intubation with simulated difficult airway.

Methods

With approval from the Institute-Government Medical College and Hospital, Chandigarh, India, the trial was registered at Clinical Trial Registry India (CTRI) vide number (CTRI/2018/02/011733). A written informed consent was obtained from 144 patients who had an American Society of Anaesthesiologists (ASA) physical status of I or II, and adult patients (18-60 years old) were scheduled for various surgical procedures under general anaesthesia.

Patients were excluded if they had a history of known or predicted difficult airway (Airway Difficulty Score > 8),[11] body mass index (BMI) >35 kg m^{-2}, or increased risk of regurgitation and aspiration of gastric content and pregnant patients, previous upper gastrointestinal surgery, coagulopathy or history of anticoagulant use, cardiorespiratory or cerebrovascular disease, cervical spine pathology, and pregnancy.

Main Points

- Stylets play an important role in ease of insertion of endotracheal intubation via C-MAC videolaryngoscope.
- The effective shaping of stylet needs great attention. Adequate hockey-shaped stylet becomes most useful aid for increase in incidence of "first time successful" intubation.
- The sympathetic stimulation with the use of videolaryngoscopes is decreased significantly when appropriately shaped stylets are used.

The study design was single blind prospective, randomised, and controlled. Using a computer-generated random number table, the patients were randomly allocated to four groups of 36 patients each. Allocation concealment was performed using sequentially numbered, coded, and sealed envelopes. Group allocation was performed immediately before general anaesthesia. An anaesthesiologist who did not participate in anaesthesia intubation or outcome evaluation performed the randomisation.

Anaesthesiologists with more than 6 months experience with airway management using C-MAC D-Blade VL and who had performed at least 20 successful tracheal intubations with each study stylet administered anaesthesia for this study. A second anaesthesiologist recorded the data as an independent observer.

This study compared the following four intubation methods using four different stylets. For all intubations, a C-MAC D-Blade® (Karl Storz GmbH & CoKG, Tuttlingen, Germany) external imaging unit was used in the laryngoscopy.

The C-MAC D-Blade VL and study stylets were kept duly operational prior to induction. An appropriate-sized ETT (size 7.0-7.5 mm inner diameter [ID] in females and 7.5-8.0 mm ID in males) was primed with stylet according to the study group allocation prior to intubation in all the groups.

The patient was allocated to one of following four groups: Group NS: endotracheal intubation without stylet (no-stylet, NS); Group CS: endotracheal intubation with a C-MAC stylet (CS); Group DS: endotracheal intubation with D-Blade type stylet (DS); Group HS: endotracheal intubation with a hockey-stick-shaped stylet (HS) (Figure 1).

On arrival in the operation room, standard monitors were applied, and baseline parameters, i.e., heart rate (HR), continuous electrocardiogram, noninvasive blood pressure (NIBP), arterial oxygen saturation (SpO_2), and end-tidal carbon dioxide ($EtCO_2$) (S/5 Aespire®, GE Healthcare Helsinki, Finland) were recorded before induction of anaesthesia. An intravenous line was secured using a 20 G cannula on the dorsum of nondominant hand, and all patients will receive baseline normal saline infusion @10 mL kg^{-1} h^{-1} throughout the study period.

All patients were premedicated with injection (Inj.) glycopyrrolate 0.2 mg i.v. and Inj. midazolam 0.04 mg kg^{-1} i.v. 5 minutes before induction. Anaesthesia was induced in the supine position with head on a standard pillow of 7 cm in height. After 3 minutes preoxygenation, anaesthesia was induced using morphine 0.1 mg kg^{-1}, propofol 2.0-2.5 mg

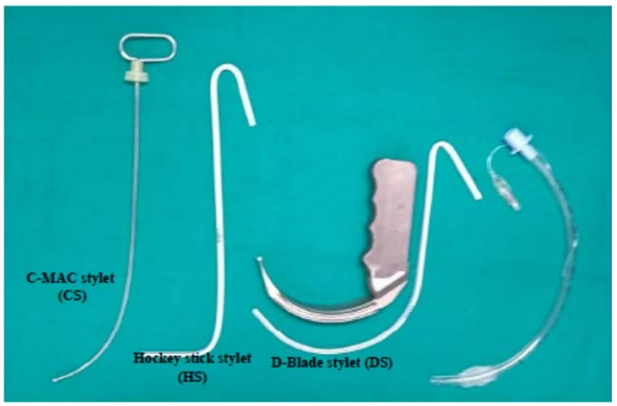

Figure 1. C-MAC stylet (CS), D-Blade stylet (DS), and hockey stick stylet (HS).

kg^{-1}. After checking for ability to achieve adequate mask ventilation, inj. vecuronium 0.1 mg kg^{-1} i.v. was used to facilitate muscle relaxation. Mask ventilation with 3-4% sevoflurane in oxygen was carried out using circle system (S/5 Aespire®, GE Healthcare) for 4 minutes. Thereafter, the pillow was removed, and a rigid appropriate-sized Philadelphia cervical collar (Vissco Rehabilitation Aids Pvt. Ltd., Mumbai, India) was placed around the neck to simulate a difficult airway.[12] After positive pressure ventilation, the trachea was intubated using the C-MAC D-Blade VL (Karl Storz, USA) using one of the stylet according to the study group allocation (NS, CS, DS, or HS groups). After evaluating the glottic view, patient's trachea was intubated by an appropriate-sized ETT.

The intubation success and the duration of intubation stages were recorded by an independent observer. A chronometer was used to record the intubation duration. The duration assessed was as follows: (1) time taken to visualise the vocal cords (the time elapsed from the moment the anaesthetist picked up the VL with D-Blade to observe the vocal cords; (2) duration of intubation: moment the vocal cords observed to ETT passed the vocal cord; (3) duration to first ventilation: inflation of the ETT cuff to the appearance of first square wave capnograph on the monitor; and (4) total intubation duration: the duration from the moment the anaesthetist picked up the VL to the appearance of first square wave capnograph on the monitor. The vocal cord images on the external imaging unit were assessed and recorded according to the Cormack Lehane grade.[13] If extra manipulation was required during intubation, the observer recorded additional laryngeal manipulation cricoid pressure with backward, upward, rightward pressure (BURP).[14] In case of failure to intubate with two attempts, the cervical collar was removed, and then intubation was performed. The case was excluded from the study.

Haemodynamic parameters (HR, NIBP (systolic, diastolic, and mean)), SpO_2, and $EtCO_2$ were recorded after induction, immediately after intubation and at 1, 2, 3, 4, 5, and 10 minutes. Any other finding like damage to the teeth, bleeding from gums or lips was recorded. Postoperative sore throat, hoarseness, and dysphagia were also assessed at every 1 hour. Rest of the anaesthesia management was as per the discretion of attending anaesthesiologists.

Sample size was estimated based on prior similar study. In five groups, difference in time to intubation was 20 seconds with a standard deviation of 15.[10] Assuming error margin of ± 2.5 seconds on sides, the mean value, and 95% confidence coefficient, optimum sample size came out to be 144, which will be divided equally in four groups. Accordingly, 36 study subjects were included in each group.

Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) version 22.0 (IBM SPSS Corp.; Armonk, NY, USA). For the descriptive statistics, categorical variables were presented as numbers and percentages. The numerical variables are presented as mean and standard deviations. Numerical variables between four independent groups were compared using Student's *t*-test for normally distributed data and Mann–Whitney *U* test for data without normal distribution. Differences between categorical variables in independent groups were tested using the Chi-square analysis. To compare the means of more than two groups, one-way ANOVA test was used, for pair wise comparison Student's *t*-test for normally distributed data and the Mann–Whitney *U* test for data without normal distribution. If differences were found in the variance homogeneity, the Bonferroni test was used.

Results

A total of 175 patients were assessed for eligibility in this study. Thirty-one patients were excluded, among which 25 did not meet the inclusion criteria, three of them refused to participate, and three of them were excluded due to postponement of surgeries. A total of 144 patients were randomly allocated to four groups of 36 patients each (Group NS, Group CS, Group DS, and Group HS). All provided consent, and none were excluded for protocol violation (Figure 2).

The demographic data were comparable in the four groups, and all groups underwent similar types and duration of procedures (Table 1).

All videolaryngoscopy provided similar glottic views at the time of tracheal intubation as assessed using Cormack/Lehane grade I/II. All intubations were completed within two attempts. More attempts were required for intubation in NS group when compared separately with the CS, DS, and HS groups ($P < .001$); however, no significant difference was

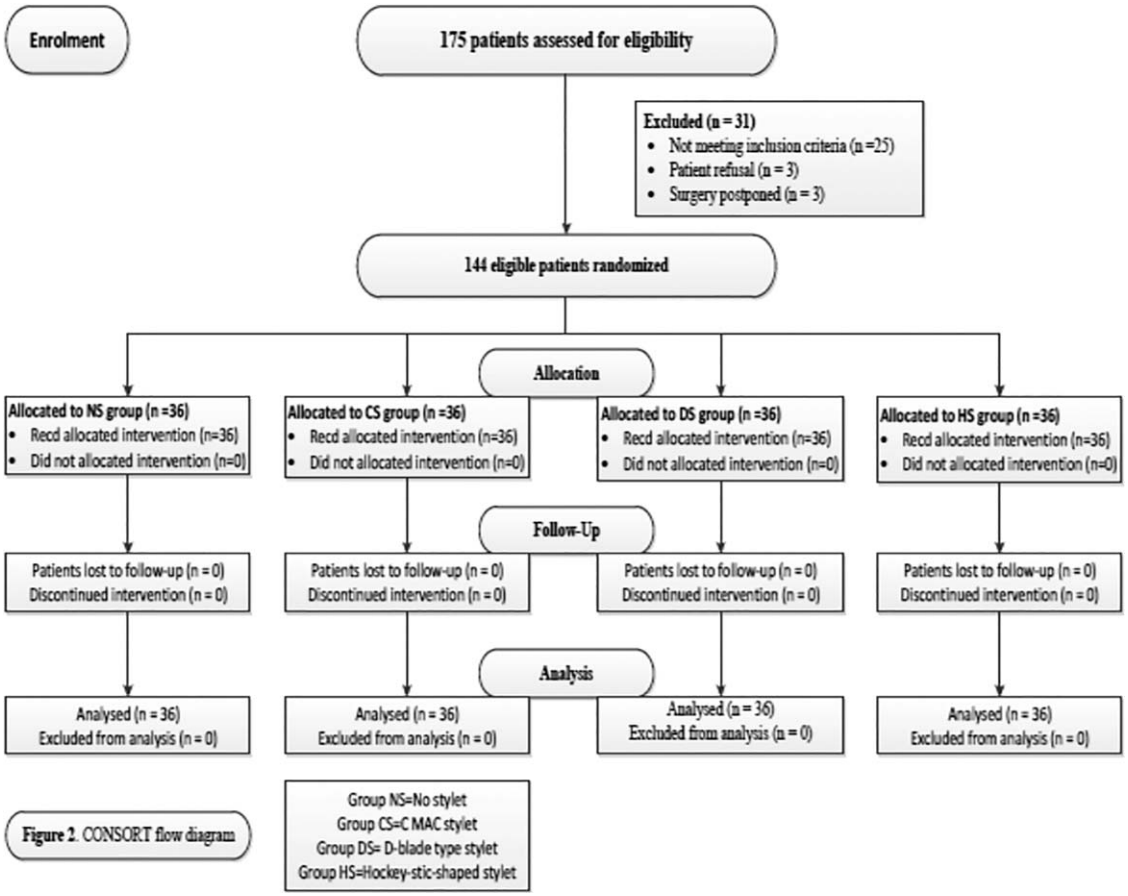

Figure 2. Consort flow diagram.

Table 1. Demographic Characteristics [Mean ± SD or Number (%)]

	Group NS (N = 36) No Stylet	Group CS (N = 36) C MAC Stylet	Group DS (N = 36) D Blade Stylet	Group HS (N = 36) Hockey Stick Stylet	*P*
Age (years)	39.47 ± 12.86	44.97 ± 12.72	43.33 ± 12.90	43.69 ± 12.73	.300
Sex (M/F)	14/22 (38.9/61.1%)	12/24 (33.3/66.7%)	15/21 (41.7/58.3%)	13/23 (36.1/63.9%)	.898
ASA (1/2)	24/12 (66.7/33.3%)	15/21 (41.7/58.3%)	17/19 (47.2/52.8%)	17/19 (47.2/52.8%)	.158
ADS	6.52 ± 0.77	6.90 ± 0.89	6.94 ± 0.92	6.89 ± 0.95	.06
Weight (kg)	63.19 ± 10.77	63.86 ± 11.76	61.33 ± 14.99	61.86 ± 11.55	.811
Height (cm)	160.7 ± 4.22	159.4 ± 5.79	159.7 ± 7.31	160.8 ± 5.35	.648
BMI (kg m^{-2})	24.41 ± 3.87	25.0 ± 4.12	23.92 ± 4.63	23.91 ± 4.38	.664

ASA, American Society of Anaesthesiologists; BMI, body mass index; ADS, Airway Difficulty Score.

observed between the CS, DS, and HS groups ($P > .05$) (Table 2).

Total duration of intubation (duration of visualising the vocal cord, intubation, and duration to first ventilation) was more in NS group (42.31 ± 8.42 seconds) as compared to rest of the three groups (CS: 30.19 ± 7.74; DS: 24.64 ± 4.31; HS: 23.47 ± 3.93 seconds). The duration was statistically highly significant ($P < .001$) (Table 2).

The duration of intubation was more in Group NS (27.22 ± 7.62 seconds) as compared to all other groups (CS: 13.00 ±

Table 2. Intubation Parameters [Mean ± SD or Number (%)]

	Group NS	Group CS	Group DS	Group HS	*P*
CL Grade (1/2)	36/0 (100/0%)	35/1 (97.2/2.8%)	36/0 (100/0%)	35/1 (97.2/2.8%)	.567
Attempts (1/2/3)	0/6/30 (0/16.7/83.3%)	33/3/0 (91.7/8.3/0%)	34/2/0 (94.4/5.5/0%)	33/3/0 (91.7/8.3/0%)	.001*
D1	8.06 ± 2.20	9.19 ± 2.77	7.94 ± 2.51	8.19 ± 2.61	.142
D2	27.22 ± 7.62	13.00 ± 6.16	8.36 ± 4.94	8.33 ± 3.21	.001*
D3	7.08 ± 1.97	8.00 ± 2.69	7.97 ± 2.71	7.00 ± 2.13	.139
TID	42.31 ± 8.42	30.19 ± 7.74	24.64 ± 4.31	23.47 ± 3.93	.001*
BURP (no/yes)	0/36 (0/100%)	35/1 (97.2/2.8%)	36/0 (100/0%)	34/2 (94.4/5.6%)	.001*

D1, Duration to visualising the vocal cords; D2, Duration of intubation; D3, Duration to first ventilation; TID, Total intubation duration; BURP, backward upward right pressure.
*Significant *P* value.

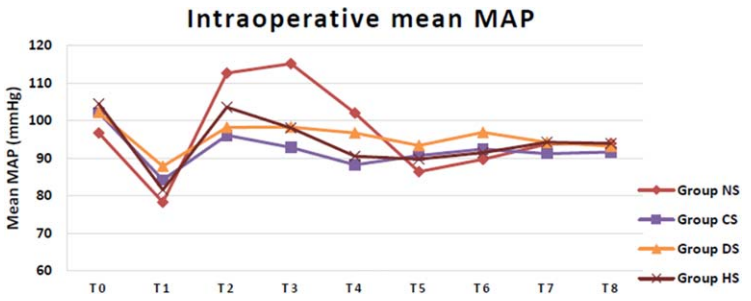

Figure 3. The mean intraoperative MAP. T0 = baseline values; T1 = after induction; T2 = immediately after intubation; T3 = at 1 minute after intubation; T4 = at 2 minutes after intubation; T5 = at 3 minutes after intubation; T6 = at 4 minutes after intubation; T7 = at 5 minutes after intubation; T8 = at 10 minutes after intubation.

6.16; DS: 8.36 ± 4.94; HS: 8.33 ± 3.21 seconds), and it was highly significant ($P < .001$). The duration of intubation in Groups DS and HS was similar but was shorter than Group CS (insignificant) (Table 2).

As an additional laryngeal manipulation, BURP was required in all the cases in Group NS as compared to one in CS, zero in DS, and two cases in HS groups ($P < .001$).

Haemodynamic parameters (HR and MAP) measured at different points of time did not differ significantly amongst the CS, DS, and HS groups. Increase in mean MAP after intubation in no stylet group was observed ($P < .05$) (Figures 3 and 4).

One patient had bleeding from lip and gums in NS group. No patient had any other complication in any group.

Discussion

Tracheal intubation is one of the most frequently used life-saving intervention during airway management. Since the development of VL, use of stylets has shown many benefits in numerous studies. After the development of conventional VLs, more angled blades were developed so as to combat difficult intubation situations. The difference in view angle of conventional C-MAC VL and D-Blade improved the

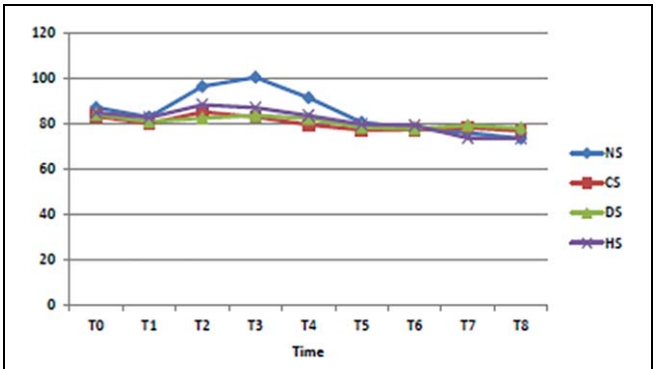

Figure 4. The mean heart rate. T0 = baseline values; T1 = after induction; T2 = immediately after intubation; T3 = at 1 minute after intubation; T4 = at 2 minutes after intubation; T5 = at 3 minutes after intubation; T6 = at 4 minutes after intubation; T7 = at 5 minutes after intubation; T8 = at 10 minutes after intubation.

operator's view during laryngoscopy; however, guiding the tube into glottis becomes difficult in many scenarios.[5,15,16]

The use of an appropriate style is necessary to advance the ETT correctly through the trachea with a C-MAC D-Blade VL. Using different types of stylets or changing the angle of stylet facilitates intubation.[16] In this study, intubation attempts and duration were assessed, and it was observed that durations involving the visualisation of vocal cords were more in "no stylet" Group NS, whereas it was similar amongst all other three groups. However, total intubation duration differed significantly between no-stylet group and using different stylets (CS, DS, and HS).

This is resulted due to the passage that ETT has to follow through trachea. The use of an appropriate stylet with C-MAC D-Blade facilitates the passage of ETT through trachea and reduces duration of intubation as well as increases the possibility of successful intubation at the first attempt. Additionally, it was possible to complete the intubation process without additional manipulation similar to found in earlier few studies.[9,10,17]

The stylet HS had also been used with VL or with conventional Macintosh laryngoscope for difficult airway interventions. A study comparing the use of different stylets with C-MAC VL found that the best performance was obtained using HS stylet type.[9] The stylet HS was prepared by angling the distal end of the intubation tube at a 90° angle, and a hockey stick like shape is made.[8,9,18] Recently, Zhu et al.[18] evaluated the ideal angulation of stylet for intubation in obese patients using McGrath MAC VL, amongst the 60°, 75°, and 90° and the angulation of 75° stylet had highest success rate with shortest time to intubation. However, using this type of stylet made stylet insertion and removal from the ETT more difficult. It has been reported that distal stylet angles of 35° and 60° passed through the trachea with more difficulty and, thus, caused more sore throats and hoarseness postoperatively.[8,18] In our study, although intubation with the HS provided better results than use of no stylet, the results obtained were similar to those obtained using a rigid stylet with smaller distal angle and those obtained using a DS stylet. The angulation of the blade of C-MAC VL is very peculiar and is helpful in the visualisation of the larynx. The angulation of stylet tip and shape of the stylet were accurately prepared, so that the subjective bias could be removed. The visualisation of laryngeal opening, shape of the stylet, and the laryngopahryngotracheal axial alignment play an important role in the smooth intubation process. The more it is anatomically configured, the more is the success rate.

Rigid stylets can alternatively be used to ease intubation through trachea when performing VL. Their use presented no advantages over malleable stylets with distal angles.[19] In the present study, C-MAC VL rigid stylet CS was used, and on extensive literature search, no study was found where this stylet was ever used. However, intubation was conducted more rapid using this stylet. There were no differences in intubation duration, success rate, and need for additional manipulation when compared to HS and DS stylets.

Although both stylets showed advantages, the stylet prepared with curvature of D-Blade angle (DS stylet) was successful equally to the other tested stylet types. Importantly, this stylet type passed the trachea most quickly, and this is probably because the angle of ETT is not at the distal end. Hence, it advanced more easily along the D-Blade curvature but not easily into the trachea.

The use of different stylets improves manoeuvrability of the ETT during intubation. On contrary, the removal of the angulated stylets posed problematic during extraction of stylet after intubation. The rigidity of the stylet in situ ETT may increase the incidence of postoperative pharyngolaryngeal complication.[20] Recently, Kotoda et al.[21] investigated the ideal technique for stylet extraction using mathematical analysis in a manikin study, which would cause minimal tube displacement. Results of their study revealed that the stylet should be diagonally extracted (in the sagittal plane) at an appropriate angle. In simulated tracheal intubation, extraction force and force applied to the vocal cords both significantly increased as the bending angle increased. Compared with the HS, the arcuate-shaped stylet resulted in reduced force.[21] In the present study, we used the well lubricated stylets and removed in the sagittal plane at an appropriate angle.

Now-a-days, VLs are commonly used for tracheal intubation, and most of the airway guidelines have included them at first step. A study compared the incidence and severity of postoperative sore throat in patients intubated with C-MAC D-Blade or traditional DL. They found reduced incidence and severity of postoperative sore throat hoarseness of voice and cough following tracheal intubation as compared to the use of DL by Macintosh laryngoscope.[19,22] In the present study, C MAC D-Blade was used with different stylets or no stylet. There were no differences in the incidence of postoperative complications such as soft tissue oedema, sore throat, and hoarseness. At 2 hours, no patient reported a sore throat or hoarseness of voice. This was similar to incidence of sore throat in previous study.[22]

The haemodynamic parameters were recorded at various time points to assess any variation in the cardiovascular response to intubation, and no significant statistical differences were observed between CS, DS, and HS groups. There was an increase in mean HR and MAP after intubation in no stylet group. This could be explained by the fact that no stylet group patients required more attempts, manipulation, and increased time during intubation. More manipulations in negotiation of the ETT might have led to increased

sympathetic stimulations, and thus haemodynamic parameter derangements. It was similarly observed by Tosh et al.[23]

Limitation

There are few limitations of this present study. First, the authors studied different stylets in simulated difficult airway not the actual patients with difficult airway, and our results may vary a little in actual difficult airway.

Second, the anaesthetist involved was not blinded to the intubation done without stylet or use of type of stylet used in a particular patient adding a source of possible bias. However, it was impossible to blind the investigators due to the nature of the equipment; hence, a bias cannot be ruled out completely. To abate it, the postoperative outcome assessor and the patients were blinded to the group assignment.

Conclusion

To conclude, this study showed that visualisation of vocal cords, during intubation with C-MAC D-Blade VL, becomes quite easy. The "first attempt successful" tracheal intubation was significantly more but similar in all the three stylet groups as compared to no-stylet group. The intubations with "no-stylet" required more time and more number of attempts to complete the intubation. The use of different stylets (HS, DS, and CS) with C-MAC D-Blade decreased total intubation duration in patients with simulated difficult airway.

Ethics Committee Approval: Ethical committee approval was received from the Institute-Government Medical College and Hospital, Chandigarh, India. (No. = IEC Regd. No. ECR/658/Inst./PB/2014 dated 1.12.2017).

Informed Consent: Written informed consent was obtained from all participants who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - L.K.A., M.S., R.G.; Design - L.K.A., M.S.; Supervision - L.K.A., M.S., S.J., M.R., A.R.; Resources - L.K.A., M.S.; Materials - R.G., S.J., L.K.A.; Data Collection and/or Processing - L.K.A., M.S., R.G.; Analysis and/or Interpretation - L.K.A., M.S., R.G.; Literature Search - R.G., L.K.A., M.S., M.R., A.R., S.J.; Writing Manuscript - L.K.A., M.S., R.G.; Critical Review - L.K.A., M.S., S.J.; Other - L.K.A., M.S., S.J., R.G., M.R., A.K.

Conflict of Interest: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

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