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Original Article

Comparison of intubation success and glottic visualization using King Vision and C-MAC videolaryngoscopes in patients with cervical spine injuries with cervical immobilization: A randomized clinical trial

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Abstract

Background: Glottic visualization can be difficult with cervical immobilization in patients with cervical spine injury. Indirect laryngoscopes may provide better glottic visualization in these groups of patients. Hence, we compared King Vision videolaryngoscope, C-MAC videolaryngoscope for endotracheal intubation in patients with proven/suspected cervical spine injury.

Methods: After standard induction of anesthesia, 135 patients were randomized into three groups: group C (conventional C-MAC videolaryngoscope), group K (King Vision videolaryngoscope), and group D (D blade C-MAC videolaryngoscope). Cervical immobilization was maintained with Manual in line stabilization with anterior part of cervical collar removed. First pass intubation success, time for intubation, and glottic visualization (Cormack – Lehane grade and percentage of glottic opening) were noted. Intubation difficulty score (IDS) was used for grading difficulty of intubation. Five-point Likert scale was used for ease of insertion of laryngoscope.

Results: First attempt success rate were 100% (45/45), 93.3% (42/45), and 95.6% (43/45) in patients using conventional C-MAC, King Vision, and D blade C-MAC videolaryngoscopes, respectively. Time for intubation in seconds was significantly faster with conventional C-MAC videolaryngoscope (23.3 ± 4.7) compared to D blade C-MAC videolaryngoscope (26.7 ± 7.1), whereas conventional C-MAC and King Vision were comparable (24.9 ± 7.2). Good grade glottic visualization was obtained with all the three videolaryngoscopes.

Conclusion: All the videolaryngoscopes provided good glottic visualization and first attempt success rate. Conventional C-MAC insertion was significantly easier.

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We conclude that all the three videolaryngoscopes can be used effectively in patients with cervical spine injury.

Key Words: Cervical spine immobilization, glottic visualization, videolaryngoscopes

INTRODUCTION

Although direct laryngoscopy has been used with variable success, it has the potential to cause greater cervical spine movement.[8,12] In the last decade indirect laryngoscopes – videolaryngoscopes (VL) – have gained popularity. Varieties of videolaryngoscopes are available in the market such as GlideScope® (Verathon Systems), C-MAC® (Karl Storz, Tuttlingen, Germany), the Airway scope® (Pentax corporation, Japan), Mc Grath MAC (Covidien, Medtronics), and King Vision Videolaryngoscope (KVVL) (King Systems, Noblesville, IN, USA). With their unique blade design and a video camera or video chip positioned close to the tip of the laryngoscope blade, can provide better visualization of glottis with minimal or no the movement of cervical spine.[4,5,15] There are mainly three types of VL; (a) with a standard Mc Intosh type of blade, (b) one with more curved/angulated blade, and (c) one with channel for endotracheal tube passage. Each design has its own advantages and disadvantages.

The C-MAC (Karl Storz, Tuttlingen, Germany) is a portable videolaryngoscope, which has similar curvature as standard Mac Intosh (C blade) and a more angulated D blade. The King Vision Videolaryngoscope (KVVL) (King Systems, Noblesville, IN, USA) is one of the new indirect laryngoscope with channeled and nonchanneled blades. KVVL has a unique design, and high quality image can prove useful in cervical spine injury patients without movement of the neck. This study compared the C-MAC (both conventional and D blade) and KVVL in patients with proven/suspected cervical spine injury on cervical immobilization in terms of first attempt intubation success, laryngoscopic view, and time for intubation.

MATERIALS AND METHODS

Approval for the study was obtained form the Institute ethics committee (project no: JIP/IEC/2014/8/365 (CTRI/2015/06/005936); and all patients signed an informed written consent. The study included adults, aged 18–60 years, with 1–2 grade American Society of Anesthesiologists (ASA) physical status and proven or suspected cervical spine injury. All were placed in cervical spine immobilization/rigid cervical collars, and scheduled for elective surgery to be performed under general anesthesia. A total of 135 patients were randomized into 3 groups (45 each): Group K (nonchanneled blade of King Vision), group C (conventional blade of C-MAC), and group D (D blade of C-MAC) was used for endotracheal intubation.

Pre-oxygenation with 100% O_2 for 3 min was done with rigid cervical collar in place. All the patients were induced with 2 μg/kg of Fentanyl, 2 mg/kg of Propofol, and muscle relaxation was achieved with 0.1 mg/kg of Vecuronium. Patients were ventilated with Isoflurane (2%) in oxygen using circle absorber system. Just before laryngoscopy, anterior part of the hard cervical collar was removed, and the spine immobilization was maintained using MILS by an assistant anesthesiologist. All the intubations were performed (as per the manufacturer recommendations) by an experienced anesthesiologist, who had done at least 30 intubations, with each device. All standard PVC-made endotracheal tube (ET tube) 8.0 was used for males and size 7.0 for females. The ET tube was pre-shaped to the shape of C type, D type, or King Vision blade using a rigid stylet.

Parameters studied

The laryngeal view was assessed using Cormack – Lehane grade (CL grade) [Table 1][7,21] and percentage of glottis opening (POGO score) [Figure 1].[12] First attempt success rate, time for intubation, time from passing of the blade through teeth to passing of the ET tube beyond glottis, also time for first appearance of end tidal CO_2 ($ETCO_2$) graph were noted. Inability to pass the endotracheal tube in two (maximum 60 s for each attempt) was considered as failure and airway was managed according to the wish of attending anesthesiologist. The ease of insertion of the scope was graded using 5-point Likert scale [Table 1].[17] The difficulty of intubation was assessed using modified intubation difficulty score (IDS) [Table 1][1,18,20] using 7 parameters. Any complications such as airway trauma, esophageal intubation, desaturation, bronchospasm, and injury to teeth were also noted.

Statistical methods

Statistical testing was conducted with statistical package for the social science system SPSS version 16.0 (Chicago, IL, USA). Results on continuous measurements are presented on Mean ± SD (Min–Max) and results on categorical measurements are presented in Number (%). Significance is assessed at 5% level of significance. Analysis of variance (ANOVA) has been used to find the significance of study parameters between three or more groups of patients, Post-Hoc Tukey test has been employed to find the pairwise significance between groups. Chi-square/Fisher Exact test has been used to find the significance of study parameters on categorical scale between two or more groups.

Table 1: Parameters used in the study

Cormack-Lehane grading (C-L grading)	Ease of insertion of videolaryngoscope	Intubation difficulty score (IDS)
Full view of vocal cords	Very easy	N1-Number of intubation attempts
Only posterior extremity of the larynx is visible	Easy	(Each supplementary attempts add 1 point)
Only epiglottis visible	Don't know	N2-Number of operators
Neither the epiglottis nor glottis seen	Difficult	(Each additional operator add 1 point)
	Very difficult	N3-Alternative technique used
		(Like bougie add 1 point)
		N4-Glottic exposure (CL grade)
		[Grade minus one (grade 1=0, grade 2=1, grade 3=2, grade 4=3)]
		N5-Lifting force applied
		(Normal=0, increased=1)
		N6-External pressure applied
		(N0=1, yes=2)
		N7-Vocal cord position at intubation
		(Abducted=1, adducted=1)

IDS interpretation. 0 – Easy, 0 to less than 5 – Slight difficulty, >5 – Moderate to major difficulty

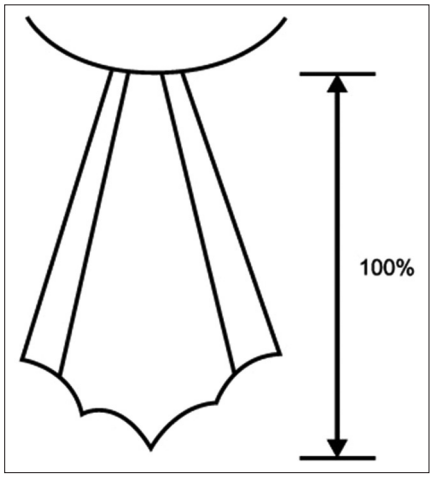

Figure 1: Percentage of glottic opening (POGO) Score

RESULTS

All three groups were comparable with respect to age [Table 2]. In group C, the mean weight and body mass index (BMI) of the patients were higher than group K [Table 2].

Visualization of the glottis

Cormack–Lehane grading and POGO scores were used for visualizing the glottis. Good grade visualization (CL grade 1 and 2) of the vocal cords was obtained in all the patients in three groups [Table 3], indicating videolaryngoscopes provided better visualization despite immobilization of cervical spine.

Glottis view is also assessed using POGO score. The mean POGO scores were comparable in group C and group K [Table 3]. Group K patients had significantly higher POGO score as compared to group D patients ($P = 0.03$).

Table 2: Demographic variables in three groups

	Group C (*n*=45)	Group K (*n*=45)	Group D (*n*=45)	*P*
Age (years)	39.4±16.9	40.1±15.4	41.6±13.5	0.79
Weight (kg)	65.3±12.2*	57.0±15.3	59.6±8.3	0.006
BMI (kg/m^2)	23.4±4.3**	20.6±4.1	21.9±3.4	0.005

Values expressed in Mean±SD. *P=0.005, **P=0.003 between group C and K Test applied, ANOVA test, *Post-Hoc* Tukey. Group C, conventional C-MAC, group K, King Vision, group D, D blade, C-MAC, *n*: Number of patients in each group, BMI: Body mass index, *P*: Significance

Table 3: Glottic view (Cormack Lehane grade and POGO score) in three groups

	Group C	Group K	Group D	*P*
CL Grade I *n* (%)	36(80.0)	32(71.1)	34(75.6)	0.62
CL Grade II *n* (%)	9(20.0)	13(28.9)	11(24.4)	
CL Grade III *n* (%)	0 (0)	0 (0)	0 (0)	
CL Grade IV *n* (%)	0 (0)	0 (0)	0 (0)	
POGO score (Mean±SD)	82.3±18.4	84.6±19.3	74.3±17.4*	0.03
POGO score (Median (IQR))	80 (80-100)	90 (75-100)	80 (60-90)	

*P=0.03 between group K and D Test applied- Chi-square test, *Post-Hoc* Tukey test. *n*=Number of patients in each group

Table 4: Success rate (Number of attempts) and Time till intubation in three groups

	Group C	Group K	Group D	*P*
Intubation success				
First attempt *n* (%)	45 (100)	42 (93.3)	43 (95.6)	0.37
Second attempt *n* (%)	0 (0)	3 (6.7)	2 (4.4)	
Time till ET tube passes the glottis (Mean±SD)	17.5±4.7	18.9±7.2	20.8±7.1*	0.05
Time till ETCO2 trace (Mean±SD)	23.3±4.7	24.9±7.2	26.7±7.1**	0.05

*P=0.04 between group C and D till ET tube passes and **P=0.04 between group C and D till ETCO2 trace. Test applied- Fisher Exact test, ANOVA test, *Post-Hoc* Tukey test

Success of intubation

Intubation was successful in all patients (100%), using all three devices [Table 4]. Intubation was completed in first attempt in 100% (45/45), 93.3% (42/45), and 95.6% (43/45) patients in group C, K, and D, respectively. Intubation was completed in second attempt in 3 patients (6.7%) in group K and 2 patients (4.4%) in group D patients. All the devices had comparable intubation success rate.

Time for intubation

Times for passing of VL through incisors to visualization of passing of ET tube through glottis and also for appearance of $ETCO_2$ tracing were noted with these devices [Table 4]. The mean time of intubation was faster in group C patients as compared to group D ($P = 0.04$ and 0.04), whereas it was comparable in group C and group K patients ($P = 0.53$ and 0.46) and group K and group D ($P = 0.37$ and 0.39) [Table 4].

Ease of insertion of laryngoscope

The curvatures of laryngoscope blades are different with King Vision and C and D blades of C-MAC devices. Hence ease of insertion was noted based on 5 point Likert scale [Table 5]. Insertion of blade was easy (grade 1and 2 in Likert scale) in 36 (80%) patients in group C and 33 (73%) in group K, as compared to only 16 (35%) patients in group D [Table 5]. Higher grades of difficulty for insertion of laryngoscope were observed in group D patients as compared to group C and group K ($P < 0.001$).

Intubation difficulty score

An IDS indicates the degree of difficulty of intubation. IDS scores were comparable in group C and group K ($P = 0.34$) [Table 6]. Difficulty in intubation was noted in 21 (47%) patients in group D as compared to 10 (22%) patients in group C ($P = 0.02$), thus indicating slight difficulty for intubation was observed with D blade of C-MAC videolaryngoscope. However, the median score of IDS was "0" in all three groups.

Alternative techniques used

Only few patients required laryngeal manueuver (2, 3, and 5 in group C, K, and D, respectively) for aiding the passage of the endotracheal tube (ET) through glottic opening ($P > 0.05$). In one patient in group K, bougie assisted endotracheal tube insertion was done.

Complications

One patient in group K had bronchospasm, following ET tube insertion and was managed according to our institute protocol.

DISCUSSION

In patients with cervical spine injury with cervical immobilization, endotracheal intubation by direct laryngoscope is difficult due to poor visualization of glottis. In these scenarios, where alignment of oropharyngeal and laryngeal axes is not possible, indirect laryngoscopes such as videolaryngoscopes play a vital role in providing optimal glottis view, without movement of cervical spine. Though C-MAC conventional blade and D blades have been used in simulated difficult airway scenarios with cervical immobilization,[4,10] literature is sparse regarding use of KVVL in these circumstances. The primary aim of our study was to explore the utility of nonchanneled blade of KVVL, C-MAC conventional, and D blades for endotracheal intubation in patients with proven/suspected cervical spine injury.

The available literature for use of videolaryngoscope is in simulated difficult airway scenarios such as, hard collar or MILS maneuver in patients with normal airways or as a teaching/testing material on manikins.[2,10,14] Our study involved all the patients with proven/suspected cervical spine injury with cervical spine immobilization. The presence of hard collar makes laryngoscopy difficult by restricted mouth opening.[9] In our study, we used hard collar for bag and mask ventilation and the accepted MILS manoeuvre, with anterior part of hard cervical collar removed for indirect laryngoscopy and intubation.[9]

Optimal visualization of the glottis is important for the success of intubation with nil/restricted spine mobility. In our study, CL grade 1 visualization was obtained in 36 (80%), 32 (72%), 34 (76%) patients with conventional C-MAC, KVVL, and D blade C-MAC videolaryngoscope, respectively. A good grade of glottis visualization (CL grade 1 and 2) was obtained in all patients. In a manikin-based study with cervical immobilization by Kılıçaslan *et al.*, good grade view (CL grade 1 and 2) was obtained by all the laryngoscopists.[11] Similar views were obtained in another manikin-based study by Jain *et al.* using C-MAC and D blade C-MAC videolaryngoscopes.[10]

Table 5: Ease of insertion of laryngoscopes in three groups

Ease of insertion	Group C *n* (%)	Group K *n* (%)	Group D* *n* (%)	*P*
1 (Very easy)	16 (35.6)	13 (28.9)	1 (2.2)	<0.001*
2 (Easy)	20 (44.4)	20 (44.4)	15 (33.3)	
3 (Don't know)	9 (20)	3 (6.7)	9 (20)	
4 (Difficult)	0 (0)	9 (20)	20 (44.4)	
5 (Very difficult)	0 (0)	0 (0)	0 (0)	

*P<0.001 between group C and D and *P<0.001 between group K and D. *n*=number of patients in each group Test applied- Fisher Exact test, *Post-Hoc* Tukey test

Table 6: IDS distribution in three groups

IDS	Group C *n* (%)	Group K *n* (%)	Group D* *n* (%)	*P*
0	35 (77.8)	31 (68.9)	24 (53.3)	0.04
0-5	10 (22.2)	14 (31.1)	21 (46.7)	
Median (IQR)	0 (0-0)	0 (0-1)	0 (0-1)	

*P=0.02 between group C and D, *P<0.001 between group K and D Test applied, Chi-Square test, *Post-Hoc* Tukey test

In a study of Alvis *et al*. comparing KVVL with Mc Grath VL, CL grade1 was obtained in 93% of patients.[3] Our study results are consistent with these studies.

The CL grading system has numerous problems. The grades are ambigious between grade 1 and grade 2.[6,21] Hence, we used POGO score as an additional measure of glottis visualization.[12] In our study, conventional C-MAC and KVVL provided better glottis visualization (82% vs. 84%, $P > 0.05$) as compared to D blade C-MAC VL (74%) [Table 3]. In contrast, 90% and 100% glottis visualization was obtained by Kılıçaslan A *et al*.[11] on simulated difficult airway in manikins. We studied mean POGO score [Table 3] compared to median by Kılıçaslan A *et al*.[11] Nowadays, keeping the tip of the blade little proximal is advocated with VL for better visualization of the tip of ET tube and easier manoeuvring of the tube in the oral cavity. This proximal placing of blade results in poor (more CL grades and poor POGO score) glottic visualization.[19]

Success of intubation

Better visualization of the glottis does not necessarily imply improved first attempt success of endotracheal intubation using VL owing to unique curvature of the blades. We used styleted ET tube, preshaped to the blade of particular VL for better visualization of the tip of the ET tube. First attempt success was noted in 100% (45/45), 93.3% (42/45), 95.6% (43/45) of the patients using conventional blade C-MAC, KVVL, and D blade C-MAC videolaryngoscopes, respectively [Table 4]. Our results are superior to the earlier published studies in the literature.[3,10,13,16] In our study, all the intubations were performed by experienced anaesthesiologists, thus improving the overall intubation success rate.

The prolonged apnea time and delayed intubation can lead to hypoxemia and desaturation in patients. Because the tube was visualized passing through the glottis, we measured both the times; (a) time from scope insertion to tube passing the glottis and (b) time from scope insertion to appearance of first $ETCO_2$ tracing on the monitor. The mean intubation times were comparable in conventional C-MAC and KVVL (23 vs. 24 s) and KVVL and D blade C-MAC (24 vs. 26 s) [Table 4]. Intubation time was significantly faster with conventional C-MAC as compared to D blade C-MAC. This prolonged time is due to increased time taken for the insertion of D blade through the mouth owing to its increased curvature of the blade as compared to conventional blade C-MAC.[19] In a study by Jain *et al*., the time for intubation were 20 and 27 s using conventional blade and D blades of C-MAC in simulated difficult airways in manikin. Our results are comparable to the study by Jain *et al*.[10] Alvis *et al*. studied Mc Grath and KVVL in adult patients noted higher intubation times with KVVL as compared to Mc Grath (38 vs. 17 s) in patients with predicted easy intubation.[3] Our study results are superior due to all the laryngoscopies were performed by anesthesiologists having experience in handling videolaryngoscpes.

One of the prerequisites for the successful laryngoscopy and subsequent intubation in patients with cervical immobilization is ease of insertion of laryngoscope blade. We graded the ease of insertion of laryngoscope blade as 1 to 5 (1, very easy to 5, very difficult). The ease of insertion of conventional C-MAC was significantly better as compared to KVVL and D blade C-MAC VL [Table 5]. The angulation of the blades of KVVL and D blade C-MAC is higher as compared to conventional blade. The KVVL blade was easier to insert as compared to D blade C-MAC VL ($P < 0.001$).

The factors which determine difficulty of intubation are number of attempts, number of operators, alternative technique used, glottis exposure, application of lifting force external pressure, and the vocal cord position. The intubation difficulty score[1,17,18] consist of these 7 parameters. Score of 0, easy intubation, <5, slight difficulty, and >5, moderate to severe difficulty. Increasing difficulty were noted with D blade C-MAC VL as compared to C blade of C-MAC VL [Table 6] with $P = 0.02$. The IDS distribution scores were comparable in KVVL and D blade C-MAC VL.

Limitations

In the present study, all the patients were intubated after induction of general anesthesia with MILS. Therefore, no post intubation neurologic assessment was done to know the effectiveness of these devices in preventing further neurological injury due to laryngoscopy and intubation.

CONCLUSIONS

In the present study, King Vision videolaryngoscopy, conventional C-MAC, and D blades were assessed for first attempt success of intubation, time for intubation, and glottic visualization.

We conclude,

- All the three videolaryngoscopes provided good first attempt intubation success
- Intubation times were faster with conventional C-MAC as compared to D blade of C-MAC. King Vision videolaryngoscope and conventional C-MAC had comparable intubation time

- All the three videolaryngoscopes provided good grade glottic visualization
- The ease of insertion of laryngoscope blade is graded as conventional C- MAC > King Vision > D blade C-MAC videolaryngoscopes.

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Conflicts of interest
There are no conflicts of interest.

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