ORIGINAL ARTICLE

Endotracheal Intubation with King Vision Video Laryngoscope vs Macintosh Direct Laryngoscope in ICU: A Comparative Evaluation of Performance and Outcomes

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Abstract

Background: Endotracheal intubation to protect airway patency in critically ill patients with the use of videolaryngoscopes has been emerging and their expertise to handle is crucial. Our study focuses on the performance and outcomes of King Vision video laryngoscope (KVVL) in intensive care unit (ICU) compared to Macintosh direct laryngoscope (DL).

Materials and methods: This comparative study was conducted by randomizing 143 critically ill patients in ICU into two groups: KVVL and Macintosh DL ($n = 73$; $n = 70$). The intubation difficulty was assessed by Mallampati score III or IV, apnea syndrome (obstructive), cervical spine limitation, opening mouth <3 cm, coma, hypoxia, anesthesiologist nontrained (MACOCHA) score. The primary endpoint was the glottic view measured by Cormack–Lehane (CL) grading. The secondary endpoints were a first-pass success, the time required for intubation, airway morbidities, and manipulations required.

Results: The KVVL group showed the primary endpoint of significantly improved glottic visualization measured in terms of CL grading compared with the Macintosh DL group ($p < 0.001$). In the KVVL group, the first pass success rate was higher (95.7%) compared to the Macintosh DL group (81.4%) ($p < 0.05$). The time required for intubation in the KVVL group (28.77 ± 2.63 seconds) was significantly less compared with Macintosh DL (38.84 ± 2.72 seconds) group ($p < 0.001$). The airway morbidities observed were similar in both groups ($p = 0.5$) and the manipulation required for endotracheal intubation was significantly less ($p < 0.05$) in our KVVL group (16 cases; 23%) compared to the Macintosh DL group (8 cases; 10%).

Conclusion: We found that the performance and outcomes of KVVL in intubating critically ill ICU patients were promising when handled by experienced operators who are experts in anesthesiology and airway management.

Keywords: Airway management, Endotracheal intubation, First-pass success, Glottic view, Mallampati score, Video laryngoscopy.

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Highlights

- Airway management of critically ill patients in the ICU is crucial.
- King Vision video laryngoscope aids in successful first-pass intubation with less time required on the first attempt with an improved glottic view even in critically ill.
- It also reduces complications and needs for manipulations during intubation.

Introduction

Intubation failure can occur unexpectedly and is the second most common event reflected in the ICU as per the Fourth National Audit Project (NAP-4) of the Royal College of Anesthetists (RCA) and the Difficult Airway Society (DAS). Airway complications are more likely to happen in the ICU than in the operating room and their management is an everyday practice in ICU.[1] One of the first airway management guidelines in critical care medicine by the All India Difficult Airway Association (AIDAA) has advocated the video laryngoscope (VL) use in the ICU for intubation.[2] The role of video laryngoscopy in difficult intubation has been recognized in the DAS 2015 guidelines that recommend all anesthetists to be trained and have access to video laryngoscopy at all times.[1,3]

The King Vision™ (AMBU, Denmark) (KVVL) is a novel VL device developed for managing difficult as well as routine airways quickly and safely.[4] It is a hyper-angulated VL with an anatomically shaped blade and a channel along the curvature of the blade which can be used to preload an endotracheal tube. To the best of our knowledge, supporting evidence to describe its performance and outcomes in critically ill ICU patients is limited.[5,6] We hypothesize that endotracheal intubation with KVVL has better glottic visualization, a higher first-pass success rate, and requires less time to intubate in difficult airway patients. Hence, our objective was to compare the performance and outcomes

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of KVVL with the Macintosh DL for endotracheal intubation of critically ill patients in the ICU.

Materials and Methods

Study Design

This prospective randomized comparative study was conducted for a period of 7 months from January 2019 to July 2019 in a 38-bedded ICU, approved by the Ethics Committee of Bharati Hospital and Research Center, Pune.

Patient Selection

All patients admitted to the ICU who required urgent and elective endotracheal intubation were enrolled in the study. Exclusion criteria were as follows: (a) Patients with upper airway deformities and (b) Patients with a known history of subglottic stenosis. Consent was obtained from relatives and next of kin as obtaining prospective informed consent from the patients was not possible before urgent airway management.

Randomization and Allocation Concealment

The patients admitted to the ICU who met the inclusion criteria were randomized into two groups at a 1:1 ratio to the use of KVVL or Macintosh DL for endotracheal intubation in the ICU. The randomization and allocation were conducted by the author who did not participate in subject recruitment to ensure allocation concealment. To achieve a similar number of participants in each group, the allocation sequence was sequentially generated by the author based on block randomization by the sequentially numbered opaque sealed envelope (SNOSE) method.

Study Protocol

After randomization, the demographics were noted. An airway examination was performed using the MACOCHA score for predicting a difficult airway. The Mallampati component of the MACOCHA score was assessed in the sitting position and whenever not possible was assessed in the supine position as validated.[7] Simultaneously, they were being optimized hemodynamically as per individual requirements, either by fluids or vasopressors based on clinical examination and point-of-care ultrasound assessment whenever possible.

All patients were pre-oxygenated using non-invasive ventilation (NIV) or bag-mask ventilation (BMV) and the drugs required for induction of anesthesia were decided upon the patient's hemodynamic and clinical characteristics. Induction agents were used at the clinician's discretion and included ketamine, propofol, etomidate, and fentanyl at recommended dosages.[8] Rocuronium was used as a muscle relaxant at an appropriate dose.[9] An arterial line was secured before induction when required. Rapid sequence intubation was done in both groups. Urgent endotracheal intubation is defined as intubation performed in the setting of acute respiratory failure, that is, failure to oxygenate or ventilate despite supplemental oxygen or NIV support and Glasgow coma scale (GCS) above 8.

Study Outcomes

The primary endpoint was glottic visualization calculated in terms of CL grading in both groups. The secondary endpoints were a first-pass success (successful intubation on the first attempt), the time required for intubation, airway morbidities, and manipulations required in both groups.

MACOCHA Score and Its Components

The MACOCHA score was used to predict difficult intubation in critically ill patients in the ICU. It ranges from 0 to 12. The difficulty of intubation increases as the score increases from 0 to 12 where zero points predict easy intubation and 12 points predict a very difficult one. The components considered for calculation of the MACOCHA score are the presence of a Mallampati score of III or IV scoring five points, obstructive sleep apnea scoring two points and cervical spine immobility, limited mouth opening, coma, severe hypoxemia, and a non-anesthetist operator scoring one point each.[2]

Method of Laryngoscopy and Intubation

Macintosh Direct Laryngoscope

The operator's left hand holding the handle of the Macintosh DL and the blade was introduced from the right angle of the mouth. The blade glided over the tongue, pushing it to the left of the oral cavity. As the blade was further advanced and positioned in the vallecula, an upward-lifting force generated from the left elbow was used to lift the epiglottis and visualize the glottis. The glottic view was optimized with the help of the back, upward, right lateral, and pressure (BURP) maneuvers when it was more than CL grade 2a. The stylets might be used to facilitate endotracheal intubation.

King Vision Video Laryngoscope

The KVVL channeled blade was preloaded with the appropriate size endotracheal tube. After preoxygenation and rapid sequence induction, it was introduced from the center of the mouth. The blade was passed along the curvature of the tongue under vision. When inserting the laryngoscope blade and the endotracheal tube into the oropharynx, the operator looked in the patient's mouth, instead of the video screen, to avoid injury to the teeth and soft tissue.

Once it reached behind the tongue, the screen was visualized and the view of the glottis was optimized. Resting the blade tip at the base of the tongue near the vallecula, the tube was slid through the channel of the laryngoscope till the black mark on the tube lays beyond the glottis. The endotracheal tube was dislodged from the channel and the KVVL was withdrawn.

Time Required and Attempts of Intubation

The time required for intubation was measured from the moment the tip of the laryngoscope blade enters the oral cavity in both groups till confirmation of endotracheal intubation by five-point auscultation. An attempt at intubation was defined as introducing the laryngoscope in the oral cavity irrespective of whether endotracheal intubation is achieved. The CL grading for the glottic view was noted by the operator in both groups and even corroborated by the assistant in the KVVL group.

Management Plan for Failed Intubation

All India Difficult Airway Association guidelines[2] for tracheal intubation in the ICU were followed when intubation required more than two attempts. The difficult airway trolley was stocked as per the AIDAA recommendations.[2]

Sample Size Estimation

The sample size calculation was based on a pilot study comparing KVVL and Macintosh DL for endotracheal intubation in patients undergoing general anesthesia. It was considered that the primary endpoint of laryngeal view of CL grade 1 will be obtained in 75%

and 50% of the patients in the KVVL and Macintosh DL groups, respectively. We estimated a sample size of 116 in total with a minimum of 58 patients in each group to detect the difference between 2 groups with a two-tailed α of 0.05 and a $(1 - \beta)$ of 0.80.

Statistical Analysis

Continuous variables were expressed in mean ± SD whereas, categorical variables were expressed in numbers and percentages (%). The continuous variables were analyzed using Student's *t*-test and analysis of variance (ANOVA). The Chi-squared (χ^2) test and Fisher's exact test were used to compare the categorical variables. All the analyses were performed using SPSS software version 22 (IBM). A two-tailed *p*-value of 0.05 was considered significant.

Results

A total of 143 patients involved were randomized into two groups (KVVL and Macintosh DL) to undertake either of the two intubations. Hundred and eleven cases (77.6%) in the study were males whereas the male-female ratio in both groups was similar. There was no significant difference between the two groups in terms of age and gender distribution (Table 1).

The MACOCHA score for difficult intubation in both groups was assessed. We could not obtain a full MACOCHA score in 36 patients (51.42%) of the Macintosh DL group and 38 patients (52%) of the KVVL group. It was because of the difficulty in obtaining the Mallampati component in comatose patients. They were considered non-measurable (NM) (Tables 1 and 2).

The number of patients in whom the Mallampati score was NM in both groups was almost similar and considered statistically insignificant ($p = 0.7$). There was an equal number of patients with Mallampati grades I, II, and III in both groups.

There was one patient with Mallampati grade IV in the KVVL group (Table 2). The cervical spine mobility was restricted in 4 patients (5.71%) of the Macintosh DL group and 6 patients (8.21%) in the KVVL group. The restrictions were due to the application of a rigid cervical collar in both groups.

Reduced mouth opening defined as less than 3 cm was seen in 2 patients (2.73%) in the KVVL group (Table 2). However, that did not impair the passage of the KVVL. The KVVL channeled blade with a thickness of 20 mm (2 cm) was enough to pass through the mouth opening of 2.4 cm in one patient and 2.6 cm in another patient.

Patients with coma were similarly distributed in both groups and the difference in the number of comatose patients in both groups was not significant ($p = 0.5$). The causes of coma included head injury, metabolic encephalopathy, cerebral vascular accidents, hypertensive intracranial hemorrhage, acute ischemic stroke, and cerebral venous sinus thrombosis.

The other components of the MACOCHA score such as obstructive sleep apnea, severe hypoxemia, and operator specialty (anesthetist vs non-anesthetist) were observed to have no significant differences ($p > 0.05$) in both groups.

Primary Outcomes

In the KVVL group, 57 patients (78%) and 16 patients (21%) had CL grades 1 and 2a, respectively, compared to the Macintosh DL group in which 6 patients (8.5%) and 48 patients (68.5%) had CL grades 1 and 2a, respectively. Worsen glottic views such as 2b and 3 were seen in 14 (20%) and 2 (2.86%) patients, respectively, in the Macintosh DL group. Grade 4 was absent in both groups.

Table 1: Patient demographics and components of MACOCHA score (subgroup analysis between MDL and KVVL groups)

Parameter	*Group* MDL ($n = 70$)	KVVL ($n = 73$)	*p-value*
Demographics			
Age, (mean ± SD)	46.04 ± 14.81	50.09 ± 15.67	0.92
Gender, *n* (%)			
• Male	54 (77.14)	57 (78)	0.89
• Female	16 (22.86)	16 (22)	
Mallampati score			
• I	1 (1.42)	1 (1.37)	0.70
• II	18 (25.7)	18 (24.7)	
• III	15 (21.4)	15 (20.54)	
• IV	–	1 (1.37)	
• NM	36 (51.4)	38 (52.05)	
Components of MACOCHA score			
Obstructive sleep apnea			
• Present	10 (14.3)	7 (9.6)	0.40
• Absent	60 (85.7)	66 (90.4)	
Cervical spine restriction			
• Present	4 (5.7)	6 (8.2)	0.70
• Absent	66 (94.3)	67 (91.8)	
Limited mouth opening			
• Present	–	2 (2.73)	0.30
• Absent	70 (100)	71 (97.26)	
Coma			
• Present	36 (51.4)	38 (52)	0.50
• Absent	34 (48.6)	35 (48)	
Severe hypoxemia			
• Present	44 (62.86)	44 (60.27)	0.60
• Absent	26 (37.14)	29 (39.73)	
Operator speciality			
• Anesthetist	70 (100)	71 (97.26)	0.3
• Non-anesthetist	–	2 (2.73)	

KVVL, King Vision video laryngoscope; MDL, Macintosh direct laryngoscope; NM, non-measurable

We observed a significantly improved glottic visualization with the KVVL group ($p < 0.001$) (Table 3).

Secondary Outcomes

In the Macintosh DL group, 57 patients (81.42%) were intubated at the first attempt and 13 patients (18.57%) were intubated at the second attempt. Whereas in the KVVL group, 70 patients (95.89%) were intubated at the first attempt and only 3 patients (4.1%) were intubated at the second attempt. The between-group comparison revealed a significant difference ($p < 0.05$) (Table 3).

In comparison between the two groups, the time required for intubation with the KVVL device was significantly shorter than the Macintosh DL group ($p < 0.001$) (Table 3).

There was no difference noted in the incidence of airway morbidities i.e., gum bleed/injury, mucosal injury, and tongue bleeds between both groups ($p > 0.05$) (Table 3).

Table 2: MACOCHA score (sub-group analysis between MDL and KVVL groups)

	MACOCHA score								
Group	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*NM*	*p-value*
MDL ($n = 70$)	14 (20)	5 (7.14)	–	–	3 (4.3)	10 (14.3)	2 (2.86)	36 (51.4)	0.80
KVVL ($n = 73$)	13 (17.8)	4 (5.48)	1 (1.37)	–	4 (5.48)	12 (16.43)	1 (1.37)	38 (52)	

KVVL, King Vision video laryngoscope; MDL, Macintosh direct laryngoscope; NM, non-measurable

Table 3: Outcomes of intubation (sub-group analysis between MDL and KVVL groups)

	Group		
Outcomes	*MDL ($n = 70$)*	*KVVL ($n = 73$)*	*p-value*
Primary endpoint			
CL grade – Glottic view, *n* (%)			
• 1	6 (8.6)	57 (78)	0.001
• 2a	48 (68.6)	16 (22)	
• 2b	14 (20)	–	
• 3	2 (2.8)	–	
Secondary endpoints			
Number of attempts, *n* (%)			
• 1 (first-pass success)	57 (81.4)	70 (96)	0.02
• 2	13 (18.6)	3 (4)	
Time required to intubate, seconds (mean ± SD)	38.84 ± 2.72	28.77 ± 2.63	0.001
Airway morbidity, *n* (%)			
• Gum bleed/injury	6 (8.6)	1 (1.4)	
• Mucosal injury	2 (2.8)	–	
• Tongue bleed	–	1 (1.4)	0.5
• None	62 (88.6)	71 (97.2)	
Manipulation required, *n* (%)			
• At oropharynx	–	1 (1.4)	
• At incisors/gums	–	1 (1.4)	
• BURP maneuver	7 (10)	–	
• BURP/stylet	9 (13)	–	
• In the oral cavity	–	2 (2.7)	0.04
• Remove/reinsert/fogging	–	1 (1.4)	
• Withdraw scope	–	3 (4)	
• No manipulation	54 (77)	65 (89.1)	

BURP, back, upward, right lateral, and pressure; CL grading, Cormack–Lehane grading; KVVL, King Vision video laryngoscope; MDL, Macintosh direct laryngoscope

In the Macintosh DL group, external laryngeal manipulation using BURP maneuver and stylet was required for 16 cases (23%) whereas, in the KVVL group, 8 cases (10%) required manipulation to facilitate passage at various points in the upper airway like at the incisors/gums, in the oral cavity, at oropharynx, removing and reinserting due to fogging of the lens and withdrawing scope when the lens was excessively close to the glottis. The overall manipulation required in the KVVL group was significantly less ($p < 0.05$) (Table 3).

Discussion

The NAP-4 report of airway events in the ICU identified that unavailability of appropriate equipment, failure to use the right equipment, and lack of training to use the right equipment were a few of the common issues with airway management in the ICU.[1] The VL use is mentioned in both AIDAA and DAS intubation guidelines for endotracheal intubation in ICU.[2,3] Current evidence highlights the importance of training in successful intubation with VL.[10]

The usefulness of VL for endotracheal intubation in critically ill is much debated. It has been shown to be useful for improving glottic vision. Nevertheless, other outcome parameters such as first attempt success and time required to intubate have not shown uniform results in randomized controlled trials.[11,12] Earlier meta-analyses had not shown any improvement in the first-pass success of intubation using VL.[13,14] Meta-analyses by Arulkumaran et al.[15] and de Jong et al.[16] recently analyzed better improvements in the first-pass success of VL in the ICU, but with moderate heterogeneities (i^2) of above 50% and 68%, respectively. So, considering the prevalence of high uncertainty, we conducted this study.

We studied a total of 143 patients requiring endotracheal intubation in the multidisciplinary Intensivist led 38 bedded mixed medical-surgical ICU of a tertiary teaching hospital. Patients who met the predetermined criteria were included in the study. We did not encounter any patients with the exclusion criteria. The groups were comparable in terms of age and gender distribution.

The MACOCHA score was used to predict difficult intubation in the study. We were unable to obtain the Mallampati component of the MACOCHA score in comatose patients.

In this study, the first-pass success was higher in the KVVL group (96%) compared with the Macintosh DL group (81.4%) ($p < 0.05$). Similar findings were noted in a study by Lakticova et al.[17] that compared Glidescope VL with Macintosh DL in ICU patients. Their first-pass success rates in the VL and the DL groups were 79% and 54%, respectively ($p < 0.0001$). The higher failure of first-pass intubation in their DL group might be due to the less experienced operators in terms of airway management due to a non-anesthesiology background.[17] Training in airway management is crucial for successful endotracheal intubation with VL or DL in ICU as evidenced by it being a component of the MACOCHA score.[2]

The time required for intubation in our KVVL group was less (28.77 ± 2.63 seconds) compared to the Macintosh DL group (38.84 ± 2.72 seconds) (i.e., $p < 0.001$). In a study by Griesdale et al.,[18] the time required for intubation was more in the VL group (Glidescope) although statistically insignificant ($p = 0.15$). The authors reasoned that might be due to the lack of experienced operators who were non-anesthetists.[18]

In this study, the primary endpoint of glottic visualization calculated in terms of CL grading was better and the secondary outcomes like higher first-pass success rate and less mean time required to intubate were observed. It was because all the intubations in the Macintosh DL group and 98.5% in the KVVL group were performed by the primary author, who was a Critical care resident and qualified anesthetist experienced in airway management with both DL and VL.

In this study, better glottic views were observed in the KVVL group. The CL grade 1 glottic view was obtained in 78% of patients in the KVVL group and in 8.6% of the Macintosh DL group in our study ($p < 0.001$). In a study by Sulser et al.,[19] a CL grade 1 glottic view was reported in 81% of the C-MAC VL group and 50% of the DL group. This study was similar to Sulser et al.,[19] in terms of study design, clinical setting, and scoring system used for grading glottic visibility, that is, CL grade.

There was no significant difference between both groups in the incidence of airway morbidity ($p = 0.5$). Only 11% ($n = 8$) in the KVVL group required manipulation during endotracheal intubation compared with the Macintosh DL group which was 23% ($n = 16$) ($p < 0.05$), it was partly similar to a randomized control trial by Jungbauer et al.,[20] where patients undergoing endotracheal intubation for general anesthesia, required a lesser number of optimizing maneuvers with VL. The optimizing maneuvers were external manipulation of the larynx (BURP maneuver), use of gum elastic bougie, and changes in head positioning.[20]

Endotracheal intubation with VL performed by trained intensivists is effective in managing difficult airways in the ICU.[21] The primary endpoint and secondary endpoints except for airway morbidity observed were significantly better in our KVVL group. We suggest that all intensivists should be trained in performing VL for successful airway management in the ICU where physiologically and the anatomically difficult airway is common.

Limitations

The pre-induction resuscitation and induction agent choice could not be fixed because of the heterogeneity of the hemodynamic states of patients requiring endotracheal intubation in the ICU. MACOCHA score has not been validated for use with video laryngoscopy but is the only validated method of airway assessment in the ICU. The Mallampati component of the MACOCHA score was NM for more than half of the patients. Ideally, in encephalopathic patients, it should have been assessed before they developed encephalopathy for improved capture of the Mallampati component.

Although the $EtCO_2$ waveform is the gold standard for confirmation of endotracheal intubation used in many trials, we used 5-point auscultation because of the inadequate availability of $EtCO_2$ sensors to all our ICU and HDU multiparameter monitors. Since the operator had prior experience with KVVL and Macintosh DL, the generalizability and applicability of our study results may vary based on the individual experience of the operators.

Conclusion

We conclude that the number of attempts, the time required for intubation, and the need for manipulations in critically ill patients were significantly less with a better glottic view when performed with KVVL. The operator's experience in video laryngoscopy, anesthesiology, and airway management might have played an important role in obtaining better outcomes.

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