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ORIGINAL ARTICLE

Comparison of intubation performance between the King Vision and Macintosh laryngoscopes in novice personnel: a randomized, crossover manikin study

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Abstract
Purpose The King Vision laryngoscope is a newly developed video laryngoscope. We conducted a simulation study to evaluate the efficacy of the King Vision in novice personnel.
Methods Thirty-one registered nurses with no previous experience with tracheal intubation were enrolled. Participants made 6 consecutive attempts at intubation of the manikin's trachea with a Macintosh laryngoscope (MAC) and the King Vision with channeled blade (KVC) and non-channeled blade (KVNC) in a randomized cross-over fashion. The Grading Scale of Intubation Difficulty (GSID) was rated on a 5-point scale.
Results Overall median (range) intubation times (sec) were 16.9 (8.0–60.0) with the MAC, 20.5 (7.2–60.0) with the KVC, and 60.0 (11.0–60.0) with the KVNC. The KVNC required significantly longer intubation time compared with the MAC or the KVC ($p < 0.001$). Success rate with the KVNC was 47.3 %, which was significantly inferior to that with the MAC (91.4 %) or KVC (86.6 %). Median GSID was 2 (range 1–5) with the KVC and 3 (1–4) with the MAC, which were both significantly lower than the 4 (2–5) with the KVNC ($p < 0.001$). Esophageal intubation with the MAC occurred in 18 of 186 attempts, whereas no incidents of esophageal intubation occurred with the KVC or KVNC.
Conclusion The KVC facilitated intubation by novice personnel without incidence of esophageal intubation. However, intubation times, success rates, and GSID scores were similar to the values obtained with the MAC. These findings suggest that the KVC, but not the KVNC, could be used as an alternative device for intubation by novice personnel.

Keywords Tracheal intubation · Airway · Simulation

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Introduction

Securing an airway by tracheal intubation with the Macintosh laryngoscope (MAC) is recognized as the gold standard. However, tracheal intubation using a direct laryngoscope requires alignment of the oropharyngeal-laryngeal axes for visualization of the glottis and is a technical skill difficult to acquire and maintain [1–4].

Recently, indirect laryngoscopy has become a widely accepted method for learning the techniques of the airway management [5] because it facilitates easy visualization of the glottis without a direct line of sight [6–8]. The King Vision laryngoscope (King Systems, Noblesville, IN, USA) is a newly developed video laryngoscope that consists of a 2.4-inch reusable display and a disposable rigid blade (Fig. 1). There are two blade types: one is a channeled blade that allows a preloaded tracheal tube to be threaded through the glottis, and the other is a non-channeled blade. With the non-channeled blade, the King Vision only provides visualization of the glottis, and intubation is facilitated by use of a metal stylet. To date, there has been no

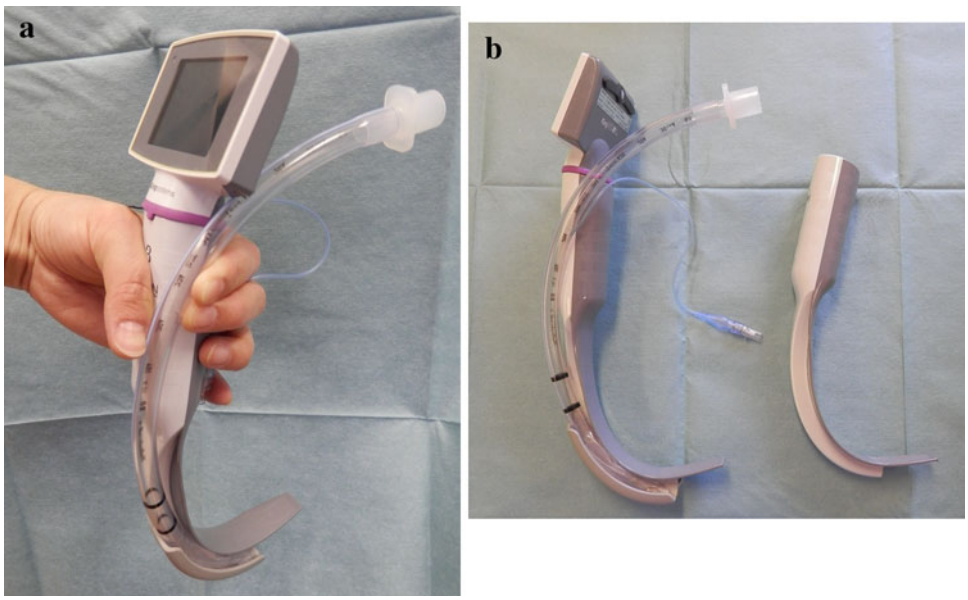

Fig. 1 **a** Photograph showing typical use of the King Vision with channeled blade. **b** Photograph of the King Vision showing the channeled and non-channeled blade

systematic study conducted to evaluate the efficacy of the King Vision in novice personnel. We hypothesized that the King Vision would prove as equally superior to the MAC as are other indirect laryngoscopes when used by novice personnel.

The purpose of this study was to compare in a randomized cross-over manner the ease of intubation between the MAC and the King Vision with channeled blade or non-channeled blade in a manikin by novice personnel.

Materials and methods

The present study was approved as being exempt by the ethics committee of University Hospital Mizonokuchi, Teikyo University School of Medicine. Written informed consent was obtained from all participants.

Subjects

Thirty-one registered nurses with various years of clinical experience who worked in operating rooms and wards were enrolled in this study. None of the participants had any previous experience with tracheal intubation. Prior to the study, each participant received a technical briefing for several minutes on intubation using the MAC with a size 3 blade (Fiber Optic Laryngoscope Blades and Handles; Welch Allyn, Skaneateles Falls, NY, USA), the King Vision video laryngoscope with a size 3 channeled blade (KVC), and the King Vision video laryngoscope with a size 3 non-channeled blade (KVNC) according to the manufacturers' instructions in the operating room. Concurrently, demonstration of intubation was performed with the three devices by one of the investigators (A.Y., K.Y., or M.K.), but the participants were not allowed to perform a practice attempt. All tracheal intubations were performed with a tracheal tube with a standard cuff and 8.0-mm internal diameter (Lo-Contour Murphy; Mallinckrodt Medical, Athlone, Ireland) in a manikin (ALS SkillTrainer; Laerdal, Stavanger, Norway) set in a neutral head position. After the tracheal tube was appropriately lubricated with silicone aerosol spray, a metal stylet was inserted in the tracheal tube when the MAC or the KVNC was used but not when the KVC was used.

Study protocol

On the day of study, the sequence of device use was assigned by drawing lots. Six consecutive intubations were performed per device; thus, the total number of intubations per person was 18, and the total number of intubation attempts for each airway device was 186 (6 attempts $\times$ 31 participants). Intubation time was defined as the time from taking hold of the handle of the device until confirmation of adequate tracheal tube position by inflating the manikin's lung with a ventilation bag. After completing all intubations, each participant was asked to rate the degree of difficulty of intubation using a 5-point Likert scale for each device, which we defined as the Grading Scale of Intubation Difficulty (GSID): (1) very easy, (2) easy, (3) moderate, (4) difficult, and (5) very difficult. Failed intubation was defined as an elapsed intubation time of more than 60 s, and the intubation time was recorded as 60 s for a failed intubation. Additionally, the incidence of esophageal intubation was noted. When esophageal intubation occurred, the tracheal tube was removed and another attempt was made. In the case of esophageal intubation, the

intubation time was the sum of the elapsed times for esophageal intubation and subsequent intubation, but a maximum of 60 s was allowed for these consecutive trials.

Data analysis

The main endpoint was to characterize the ease of intubation using the KVC or KVNC. The data from intubation times and success rates were compared with the MAC as objective indices, and the GSID score was compared as a subjective index, of the difficulty of intubation. We also compared the incidence of esophageal intubation as an index of complications associated with intubation.

Statistics

Data are presented as median (range) unless stated otherwise. Comparisons of overall intubation times and GSID scores between the three airway devices were made by Wilcoxon's signed rank test with Bonferroni correction. The intubation times between the three airway devices in each attempt were also compared using the Wilcoxon's signed rank test with Bonferroni correction. Comparison of the success rates of tracheal intubation and the incidence of esophageal intubation between the three airway devices was made by Chi squared tests with Bonferroni correction. The intubation time and the success rate with each device were compared between the first to third attempts and the fourth to sixth attempts using the Wilcoxon signed-rank test and the Chi square test, respectively. The data were analyzed with SPSS 11.0 J for Windows software (SPSS Japan Inc., Tokyo, Japan). Values of $P < 0.05$ and $P < 0.0167$ (=0.05/3) were considered statistically significant for comparisons between two sets of paired data and among three sets of paired data, respectively. Sample size was calculated based on our pilot study of the measurement of success rate of tracheal intubation between the three airway devices. Assuming a difference in success rates of 40 % between the MAC and the KVC or KVNC, we found that a total of 30 participants would be required to detect a significant difference ($\beta = 0.2$; $\alpha = 0.05$). To ensure a safety margin, we recruited 31 participants in this study.

Results

Study population

Thirty-one nurses were recruited, and all of them consented to participate in the study. Their median experience in clinical practice was 9 (1–35) years. All participants successfully completed this study (Fig. 2).

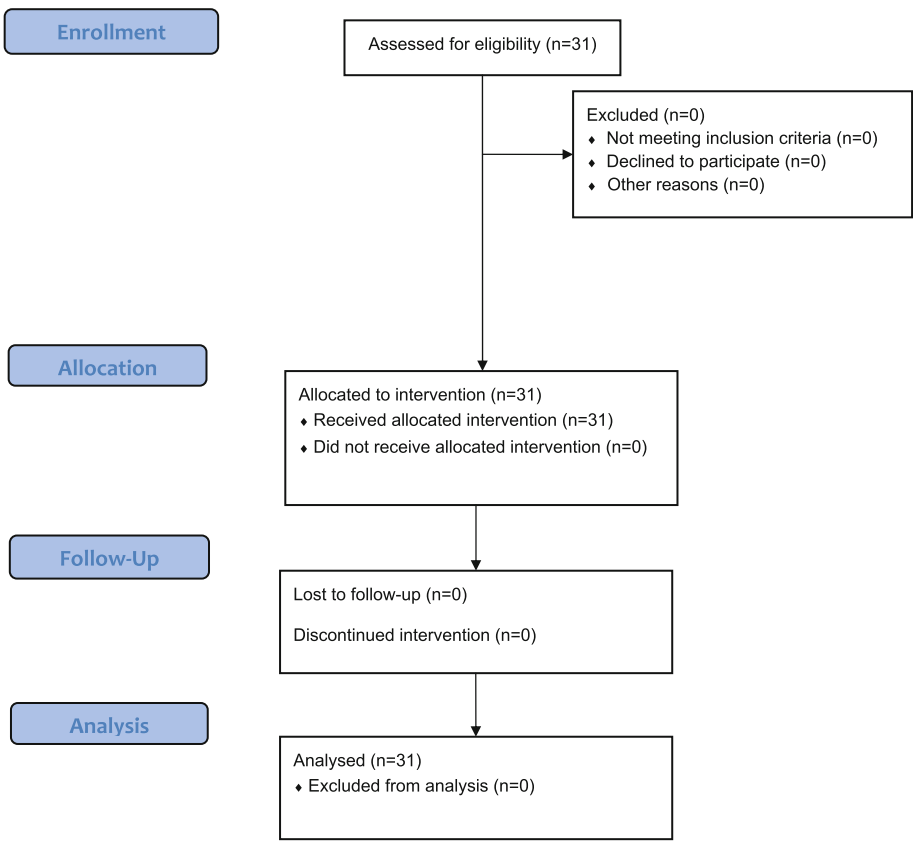

Fig. 2 Flow diagram of the participants included in this study

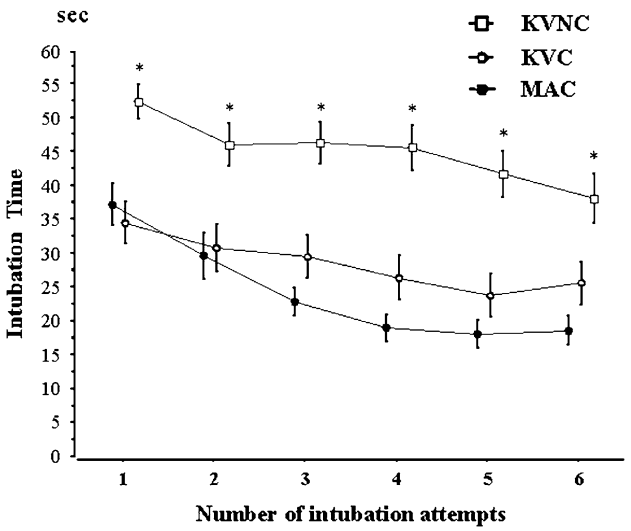

Fig. 3 Changes in intubation time during 6 attempts with the MAC, KVC, and KVNC. *MAC* Macintosh laryngoscope, *KVC* King Vision with channeled blade, *KVNC* King Vision with non-channeled blade. Data are shown in the mean (SEM) to simplify the data display, though data were analysed using Wilcoxon test with Bonferroni correction. *$P < 0.01$ compared with the KVNC

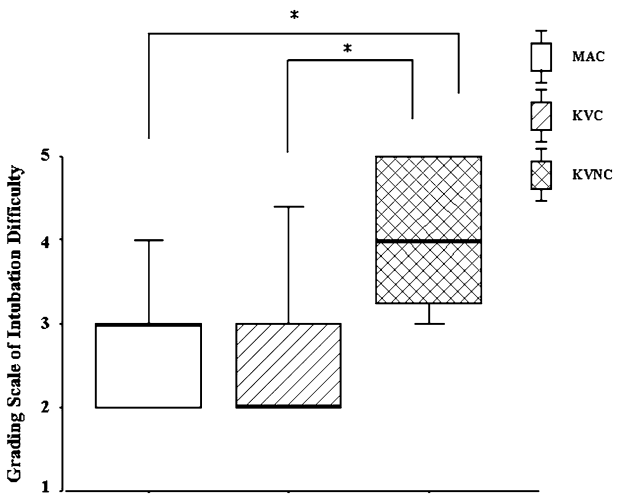

Fig. 4 Grading Scale of Intubation Difficulty scores for the MAC, KVC, and KVNC. The *central bold horizontal line* indicates the median, the *boxes* indicate the lower and upper quartiles, and the *lower and upper whiskers* indicate 10th and 90th percentiles, respectively. *MAC* Macintosh laryngoscope, *KVC* King Vision with channeled blade, *KVNC* King Vision with non-channeled blade. $N = 31$. *$P < 0.001$ compared with the KVNC

Comparison of intubation time, success rate, and GSID between the devices

Overall median intubation time was 16.9 (8.0–60.0) s with the MAC, 20.5 (7.2–60.0) s with the KVC, and 60.0 (11.0–60.0) s with the KVNC. The KVNC required significantly longer intubation time compared with the MAC or the KVC ($P < 0.001$). The change in intubation time in a series of 6 attempts with each device is shown in Fig. 3. The intubation time with the KVNC was always longer than that with the MAC or the KVC throughout the study ($P < 0.001$). There was no significant difference in intubation times between the MAC and the KVC. The overall success rate of intubation with the three devices was 91.4 % (170/186) with the MAC, 86.6 % (161/186) with the KVC, and 47.3 % (88/186) with the KVNC. There was no significant difference in success rates between the MAC and the KVC; however, the success rate with the KVNC was significantly inferior to that with the MAC or the KVC. Median GSID score was 2 (1–5) with the KVC and 3 (1–4) with the MAC, which were both significantly lower than the 4 (2–5) obtained with the KVNC (Fig. 4).

Incidence of esophageal intubation

Esophageal intubation occurred 18 times in 186 attempts by 13 of the 31 participants with the MAC. After these 18 incidents of esophageal intubation, tracheal intubation was successful only twice within 60 s. In contrast, no incidents of esophageal intubation occurred with the KVC or the KVNC ($P < 0.001$).

Learning effect with each device

Median intubation time in the 4th to 6th attempts was significantly shortened compared with that in the 1st to 3rd attempts with each device. Otherwise, the success rate in the 4th to 6th attempts was significantly improved over that in the 1st to 3rd attempts only with the MAC (Table 1).

Discussion

In the present study, there was no incidence of esophageal intubation with the KVC. However, intubation times, success rates, and the GSID scores did not differ from those of the MAC. Although esophageal intubation did not occur with the KVNC, its use resulted in significantly longer, less successful, and more difficult intubation compared with the MAC or the KVC.

Laryngoscopy with the MAC requires alignment of the oropharyngeal axes for visualization of the glottis. The skill required to align the oropharyngeal axes is relatively difficult to attain. Furthermore, concurrent placement of a tube into the trachea during laryngoscopy can require deft hand-eye coordination, which could be a technical burden especially for novice personnel. Recently, various types of indirect laryngoscopes have been developed. One of the characteristic advantages of these devices in intubation is

Table 1 Learning effect for each device

	MAC	KVC	KVNC
Intubation time (s)			
1st–3rd attempts	23.7† (8.0–60.0)	25.0† (8.0–60.0)	60.0 (14.7–60.0)
4th–6th attempts	14.8*,† (8.0–60.0)	17.5*,† (7.2–60)	50.8* (11.0–60.0)
Success rate (%)			
1st–3rd attempts	79/93† (84.9)	80/93† (86.0)	39/93 (41.9)
4th–6th attempts	91/93† (97.8)*	81/93† (87.1)	49/93 (52.7)

MAC Macintosh laryngoscope, *KVC* King Vision with channeled blade, *KVNC* King Vision with non-channelled blade

* $P < 0.01$, compared with 1–3 attempts using the same device

† $P < 0.01$, compared with the KNVC among the same attempts group

the provision of a view of the glottis without the need for alignment of the oropharyngeal axes [6–8]. The design of the KVC and KVNC also allows visualization of the glottis without line of sight. Another beneficial characteristic especially with the KVC is a channel to guide the tracheal tube tip, which facilitates intubation without complex manipulation of the tracheal tube. Therefore, we expected that these characteristics, easy visualization of the glottis and simple manipulation of the tracheal tube, would result in faster, more successful, and easier intubation when the KVC was compared with MAC. However, we found no superiority of the KVC or KVNC over the MAC in terms of GSID scores, intubation times, or success rates. There are several possible explanations for this finding. First, the preliminary instruction we provided might have been insufficient to make participants appropriately understand the intubation technique with the King Vision. Recently, several studies evaluating performance of the Airtraq, an indirect laryngoscope with a structure similar to that of the KVC, showed that for novice personnel, intubation time was significantly shorter with the Airtraq than the MAC [9, 10]. A 2-h demonstration of intubation techniques with 5 practice intubations was done in one study, and the other provided brief instructions but allowed 5 to 6 practice intubations before the actual intubations were performed. In the present study, we provided participants a simple, short, technical briefing on manipulation of the device, but we allowed no practice, and this could have led to poor understanding of the intubation technique with the King Vision. Although the manufacturer's instructions show that the blades allow either a Macintosh blade-like technique or a Miller blade-like technique to be used successfully, they recommended starting with the blade tip in the vallecula (Macintosh approach) to avoid going too deep (Fig. 5). We also recommended performing the Macintosh approach. Actually, however, most of participants clung to the Miller approach with the KVC or the KVNC, resulting in difficult manipulation when directing the tracheal tube toward the glottis. This might have caused the longer elapsed times for intubation with the KVC or KVNC. Additionally, there was a significant learning effect in terms of intubation time with both the MAC and the King Vision within the first 3 attempts. Therefore, practice intubations performed prior to the study, similar to the protocol of the previous study, might have elicited different results. Next, although the participants were novices at intubation, some of them had routinely assisted in intubation with the MAC as staff in the operating room. Therefore, this background information might have contributed to comparable GSID scores, short intubation times, and the increased success rate with the MAC in this study. Lastly, the KVNC is specifically associated with a different cause of more difficult intubation. We prepared an appropriately shaped metal stylet to facilitate intubation for each attempt. However, the intraoral space created by laryngoscopy with the KVNC was relatively tight, and manipulation of a tracheal tube would be rather difficult, even when clear glottic visualization was obtained, i.e., the glottis can be visualized, but intubation cannot be performed. Therefore, we assumed that this factor might have contributed to longer intubation time, less successful intubation, and the higher GSID scores observed with the KVNC.

Esophageal intubation can cause various complications including pulmonary aspiration of gastric contents, cerebral hypoxia, and cardiac arrest [11]. Although esophageal intubation occurred in approximately 10 % of the intubation attempts with the MAC, no esophageal intubations occurred with the KVC or the KVNC in this study. Presumably, the incidence of esophageal intubation occurring with the MAC was associated with the difficulty of glottic visualization during laryngoscopy with this particular laryngoscope. In contrast, we assume that the better glottic view provided by the display of the King Vision prevented misplacement of the tube in the esophagus. This result is consistent with that of previous reports comparing intubation between an indirect laryngoscope and the MAC [5, 12–14].

There are several limitations in our study. The primary limitation relates to just how realistic the upper airway of

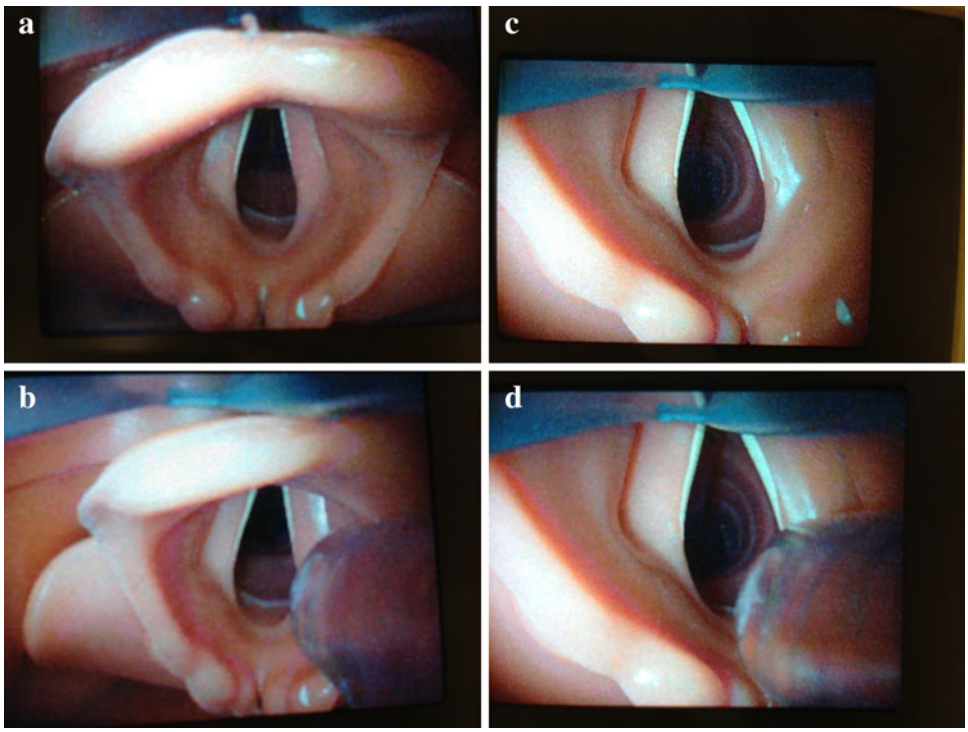

Fig. 5 Photographs of the King Vision monitor screen indicating the relative positions of the anatomical structures and the blade tip. **a** The blade tip is located in the vallecula (Macintosh-type approach). **b** The tracheal tube is threaded through the glottis via the Macintosh-type approach. **c** The blade tip passes underneath the laryngeal surface of the epiglottis (Miller-type approach). **d** The tracheal tube is threaded through the glottis via the Miller-type approach

the manikin really is. Manikin-based airway research for assessment of the efficacy of new airway devices is widely accepted [15–20]. However, there are only two studies, both reported by the same authors, that compare the anatomical similarity of manikins with actual pediatric or adult patients using computed tomographic measures [21, 22]. These studies reported considerable disparity in upper airway anatomy between the manikins and actual patients. Especially, only 1 to 6 of 19 measurements (5 to 32 %) fit within the 95 % CI of anatomical measurements in human patients in a study evaluating four adult high-fidelity manikins and two airway trainers [22]. Thus, the lack of positive data when evaluating upper-airway anatomical similarity with actual patients has brought into question the validity of manikin studies [21–23]. Because the upper airway anatomy of the manikin used in the present study has not been evaluated, the results obtained in this study might be valid only in the manikin we used. Although we agree that extensive use of human patient simulators for airway research should be discouraged, from an ethical point of view, we also believe that manikin studies offer specific benefits, especially in training for cardiopulmonary resuscitation or with novice personnel. The manikin study also may not fully reproduce laryngoscopic conditions in humans: for example, fogging of the scope caused by expiration or intraoral secretions may complicate intubation. Therefore, special attention must be paid to the interpretation of the results of this study. Second, it was impossible to blind each participant to the device being used for intubation. Some participants might recognize the benefit of indirect laryngoscopy through routine assistance with intubation because another type of indirect laryngoscope with a similar structure to that of the KVC was used in our institution. Therefore, significant bias could remain in rating the GSID score. Third, we conducted this manikin study only in a normal airway condition because difficult airway conditions, such as tongue edema or limited jaw opening, could not be reproduced in this manikin. Benefits of intubation with the KVC or KVNC would become obvious in such conditions.

In conclusion, the KVC facilitated intubation by novice personnel without incidence of esophageal intubation. However, GSID scores, intubation times, and success rates were similar to those with the MAC. Moreover, the KVNC provided significantly inferior intubation performance except for the incidence of esophageal intubation. These findings suggest that the KVC, but not the KVNC, could be used as an alternative device for intubation by novice personnel. Further study conducted in difficult airway conditions is required to evaluate the benefits of the KVC or KVNC.

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Conflict of interest None declared.

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