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SCIENTIFIC ARTICLE

Comparison of King Vision video laryngoscope and Macintosh laryngoscope: a prospective randomized controlled clinical trial



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KEYWORDS

Airway management;
Direct laryngoscopy;
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Video laryngoscopy

Abstract

Background and objectives: We compared the efficiency of the King Vision video laryngoscope and the Macintosh laryngoscope, when used by experienced anesthesiologists on adult patients with varying intubating conditions, in a prospective randomized controlled clinical trial.

Methods: A total of 388 patients with an American Society of Anesthesiologists physical status of I or II, scheduled for general anesthesia with endotracheal intubation. Each patient was intubated with both laryngoscopes successively, in a randomized order. Intubation success rate, time to best glottic view, time to intubation, time to ventilation, Cormack–Lehane laryngoscopy grades, and complications related to the laryngoscopy and intubation were analyzed.

Results and conclusions: First pass intubation success rates were similar for the King Vision and the Macintosh (96.6% vs. 94.3%, respectively, $p > 0.05$). King Vision resulted in a longer average time to glottic view (95% CI 0.5–1.4s, $p < 0.001$), and time to intubation (95% CI 3–4.6s, $p < 0.001$). The difference in time to intubation was similar when unsuccessful intubation attempts were excluded (95% CI 2.8–4.4s, $p < 0.001$). Based on the modified Mallampati class at the preoperative visit, the King Vision improved the glottic view in significantly more patients (220 patients, 56.7%) compared with the Macintosh (180 patients, 46.4%) ($p < 0.001$). None of the patients had peripheral oxygen desaturation below 94%. Experienced anesthesiologists may obtain similar rates of first pass intubation success and airway trauma with both laryngoscopes. King Vision requires longer times to visualize the glottis and to intubate the trachea, but does not cause additional desaturation.

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PALAVRAS-CHAVE

Manejo de vias aéreas;
Laringoscopia direta;
Intubação endotraqueal;
Anestesia geral;
Videolaringoscopia

Comparação entre o videolaringoscópio King Vision e o laringoscópio Macintosh: um ensaio clínico prospectivo randomizado e controlado

Resumo

Justificativa e objetivos: Comparamos a eficiência do videolaringoscópio King Vision e do laringoscópio Macintosh, quando usados por anesthesiologistas experientes em pacientes adultos com diferentes condições de intubação, em um estudo clínico prospectivo randomizado e controlado.

Métodos: Foram selecionados 388 pacientes com estado físico ASA I ou II (de acordo com a classificação da American Society of Anesthesiologists – ASA), programados para anestesia geral com intubação traqueal. Cada paciente foi intubado com ambos os laringoscópios sucessivamente, em uma ordem aleatória. A taxa de sucesso da intubação, o tempo até a melhor visualização da glote, o tempo de intubação, o tempo de ventilação, a classificação de Cormack-Lehane (graus) e as complicações relacionadas à laringoscopia e intubação foram analisados.

Resultados e conclusões: As taxas de sucesso na intubação na primeira tentativa foram similares para o King Vision e o Macintosh (96,6% vs. 94,3%, respectivamente, $p > 0,05$). As médias dos tempos até a melhor visualização da glote (IC 95% 0,5–1,4s, $p < 0,001$) e de intubação (IC 95% 3–4,6s, $p < 0,001$) foram maiores no King Vision. A diferença no tempo de intubação foi semelhante quando as tentativas malsucedidas de intubação foram excluídas (IC 95% 2,8–4,4s, $p < 0,001$). Com base na classificação de Mallampati modificada na consulta pré-operatória, o King Vision melhorou significativamente a visualização da glote em mais pacientes (220 pacientes, 56,7%) em comparação com o Macintosh (180 pacientes, 46,4%) ($p < 0,001$). Nenhum dos pacientes apresentou dessaturação periférica de oxigênio abaixo de 94%. Os anesthesiologistas experientes podem obter taxas semelhantes de sucesso na primeira tentativa de intubação e de traumas das vias aéreas com ambos os laringoscópios. O King Vision requer tempos mais longos até a visualização da glote e de intubação traqueal, mas não causa dessaturação adicional.

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Introduction

Securing the patient's airway is essential in general anesthesia. Airway management problems constitute 17% of anesthesia closed claims, with difficult intubation being the most common at a rate of 5%.¹ Problems like delayed intubation, misplaced tracheal tube, or airway trauma are frequently encountered in outpatient settings, and can cause death or hypoxic brain damage.^{2,3}

Video laryngoscopes have been proven useful for intubating patients with difficult airways.⁴ With a camera and light source on the tip of its blade, the King Vision video laryngoscope (KVVL) provides indirect glottic view without needing to align the oral-pharyngeal-tracheal axis. This allows for less tissue damage during laryngoscopy, leading to KVVL's successful use in awake intubations.⁵ Several studies have reported that KVVL provided better glottic views in comparison with other laryngoscopes when used by novice personnel or in manikin studies simulating difficult airway scenarios.^{6–8} It remains unclear, however, whether these results can translate into higher intubation success rates or shorter time to intubation when KVVL is used by experienced anesthesiologists.^{9,10}

This study aimed to compare the efficiency of using a KVVL with a standard size 3 channelled blades versus the use of a Macintosh laryngoscope, on adult patients with varying intubating conditions, scheduled for general anesthesia. In

cases where using the KVVL channelled blade proved unsuccessful, the Macintosh laryngoscope was instead compared to the KVVL using a non-channelled blade.

Materials and methods

This study was approved by the Local Ethics Committee (n° 2014/109) and registered in ClinicalTrials.gov (Identifier: NCT02482870). All patients signed an informed consent form prior to their inclusion in the study.

All patients scheduled for general anesthesia with endotracheal intubation in a University Hospital were included in the study. Exclusion criteria included emergency surgery, age below 18 years or above 60 years, inter-incisor distance <2 cm, American Society of Anesthesiologists (ASA) score >2, ankylosis, degenerative osteoarthritis, glottic or supraglottic mass (like lingual thyroid or tonsillar hypertrophy), mediastinal masses, oropharyngeal anomaly (like subglottic stenosis), and having Treacher-Collins, Pierre Robin, or Down syndrome. Patients were also excluded if they had a history of surgery, or scheduled surgery, for any of these conditions.

On the day of surgery, allocated patients were taken into the operating room and given 0.04 mg.kg⁻¹ of intravenous midazolam premedication, before their airways were evaluated and anthropometric measurements (thyromental and sternomental distance, modified Mallampati class) were recorded.¹¹ The study's flow diagram can be found

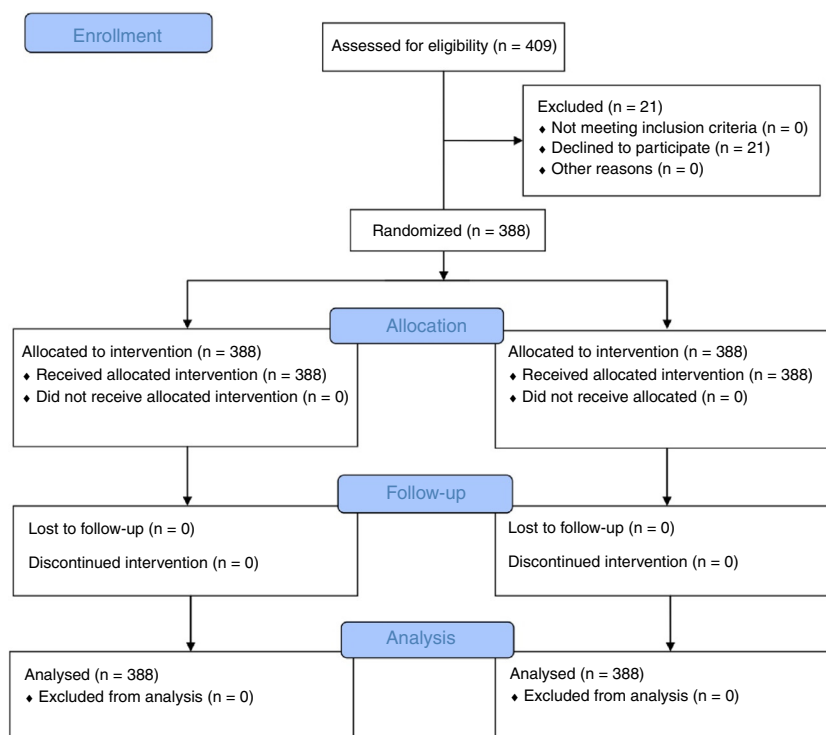


Figure 1 Consort flow diagram of the study.

in Fig. 1. Anesthesia was induced with 2 mcg.kg^{-1} of intravenous fentanyl and 2 mg.kg^{-1} of intravenous propofol, and muscle relaxation was obtained with 1 mg.kg^{-1} of intravenous rocuronium.

Following mask ventilation for 3 min, anesthesiologists experienced in video laryngoscopy performed the laryngoscopies with both a Macintosh laryngoscope, and a KVVL with a size 3 channeled blades, sequentially. They were blinded to the preoperative airway evaluation, including any history of difficult intubation, and they determined the order of the laryngoscopes by flipping a coin during the preoxygenation period. In cases where intubation using the KVVL channeled blade was unsuccessful, a non-channeled blade was used. Standard size 3 channeled and non-channeled blades were available for the KVVL, but the laryngoscopist was free to choose a suitable blade of any size for the Macintosh laryngoscope. There were a total of 5 attending laryngoscopists, with an average experience of 9.8 ± 3.3 years with Macintosh laryngoscope and 1.2 ± 0.4 years with KVVL.

The primary outcome measures were intubation success on the first attempt and the time to intubation. Secondary outcome measures were time to best glottic view, time to ventilation, Cormack–Lehane laryngoscopy grades obtained by each laryngoscope, and complications related to the laryngoscopy and intubation. Such complications included cuts, bleeding, damage to the teeth, laryngospasm, bronchospasm, desaturation below 90%, and conditions of “cannot intubate” or “cannot intubate, cannot ventilate”.

The sample size was calculated according to the first 60 patients, who had intubation success rates of 91.7% and 96.7% with Macintosh laryngoscope and KVVL, respectively. A total of 378 patients were required to obtain 90% power

with an alpha error of 0.05, but 388 patients were included to make up for possible dropouts due to recording or administrative errors.

The data were analyzed with R software (R version 3.2.5, R Foundation for Statistical Computing, Vienna, Austria). The Levene test was used to test for the normality of distributions. Parametric data (time to best glottic view, time to intubation, time to ventilation) were presented as a mean (standard deviation), and analyzed with two sample Student’s *t* test. Nonparametric data (age, height, weight, body mass index, thyromental distance, sternomental distance, inter-incisor distance) were presented as a median (IQR [range]), and analyzed with Wilcoxon rank sum test, which was also used for analyzing the improvement in glottic view. Categorical data (gender, presence of obstructive sleep apnea and snoring, ASA class, modified Mallampati class, laryngoscopy grade, occurrences of complications) were presented as a number (percentage), and analyzed with Chi-squared contingency table test. Correlation of laryngoscopy grade with variables like gender, body mass index, thyromental distance, sternomental distances, and inter-incisor distance were analyzed with multivariate logistic regression. A value of $p < 0.05$ was considered statistically significant.

Results

Data collected from 388 patients (158 female, 230 male) from January to June 2014 were analyzed. Patients showed a homogenous distribution for all demographic parameters except for age; demographic data are summarized in Table 1.

Table 1 Baseline characteristics and anthropometric variables of the patients.

Age (years)	48.5 (37–55 [18–60])
Sex (n)	
Male	230 (59.3%)
Female	158 (40.7%)
Height (cm)	171 (165–175 [149–185])
Weight (cm)	80 (70–88 [42–108])
BMI (kg.m ⁻²)	26.9 (24.3–30.9 [15.8–50.8])
History of obstructive sleep apnea	96 (24.7%)
History of snoring	142 (36.6%)
Modified mallampati class	
0	0 (0%)
1	79 (20.4%)
2	113 (29.1%)
3	107 (27.6%)
4	89 (22.9%)
Thyromental distance (cm)	6.2 (5.3–7.3 [4.1–10.3])
Sternomental distance (cm)	10.9 (9.6–12.3 [8.4–14.9])
Interincisor distance (cm)	3.3 (2.7–4.1 [2–5.1])
Physical state	
ASA I	192 (49.5%)
ASA II	196 (50.5%)

Values are expressed as median (IQR [range]) or numbers; ASA, American Society of Anesthesiologists.

Intubation success on first attempt

Intubation success on first attempt is given in Table 2. Briefly, the difference between the rates of failure of the laryngoscopes during the first attempt was not statistically significant. The data about the patients who could not be intubated with either the Macintosh laryngoscope or the KVL with the channeled blade are given in Table 3. Briefly, in cases of intubation failure, the mean time to intubation with the non-channeled blade was significantly shorter compared to both the channeled blade and the Macintosh laryngoscope ($p < 0.001$ in both cases). There were no patients who could not be intubated with at least one laryngoscope.

Time to best glottic view, time to intubation, time to ventilation

The time to best glottic view, time to intubation, and time to ventilation (total apneic period) are given in Table 2. The Macintosh laryngoscope provided an earlier view of the glottis in 250 patients (64.4%) out of 388, an earlier intubation in 288 patients (74.2%), and a shorter duration of apnea in 286 patients (73.7%), with a significantly shorter total apneic period compared with KVL. No patient was apneic for more than 107s. When unsuccessful intubation attempts with both laryngoscopes were excluded, time to intubation with both laryngoscopes were similar (Table 2) ($p = 0.068$).

Laryngoscopy grades obtained by each laryngoscope

Improvements to the glottic view with the Macintosh laryngoscope and KVL are given in Figs. 2 and 3, respectively. Using the Macintosh laryngoscope, the laryngoscopy grade improved for most patients with modified Mallampati classes 1 and 2, but stayed the same for most of those with modified Mallampati classes 3 and 4 (Fig. 2). With KVL, however, the majority of patients had improved laryngoscopy grade (Fig. 3). A comparison of the CL obtained with both laryngoscopes is displayed in Fig. 4, which shows that the KVL obtained a significant improvement to the glottic view compared with the Macintosh laryngoscope (95% CI -0.95 to -0.67 , $p < 0.001$). The CL was not strongly correlated with the modified Mallampati class in either laryngoscope. Sternomental distance was the only anthropometric variable to provide a significant correlation between modified Mallampati class and CL.

Complications related to the laryngoscopy and intubation

Complications were restricted to minor cuts on lips, affecting 4 patients with the Macintosh laryngoscope and 6 patients with KVL. There were no incidents of bronchospasm, desaturation below 94%, or a situation of ‘‘cannot intubate cannot ventilate’’. Mean saturation of peripheral oxygen was $95.8\% \pm 1\%$.

Table 2 Primary and secondary outcomes.

	Macintosh laryngoscope (n = 388)	KVVL channeled version (n = 388)	p-value	95% CI for a difference between means
Intubation success on the first attempt	366 (94.3%)	375 (96.6%)	0.1195 ^a	
Time to best glottic view (s)	7.6 (2.5)	12.6 (8)	<0.0001 ^b	0.5–1.4
Time to intubation (s)	7.9 (4.7)	23.5 (10.8)	<0.0001 ^b	3–4.6
Time to intubation when unsuccessful attempts were excluded (s)	7.2 (2.2)	8.4 (3.8)	0.068 ^b	0.1–2.4
Time to ventilation (s)	15.5 (5.6)	36.1 (13.4)	<0.0001 ^b	4.8–7.1

Values are means (standard deviation) or numbers; KVVL, King Vision video laryngoscope.

^a Chi-squared test.

^b Two sample Student's *t* test.

Table 3 Intubation success and time to intubation on the patients who could not be intubated with either one of the study laryngoscopes.

	Patients who could not be intubated with the		p-value
	Macintosh laryngoscope (n = 22)	KVVL channeled version (n = 13)	
<i>Mallampati class</i>	3 (3–4 [2–4])	3 (3–4 [2–4])	0.589 ^a
<i>History of obstructive sleep apnea</i>	17 (77.3%)	13 (100%)	0.011 ^b
<i>Intubation success on the first attempt</i>			
Macintosh laryngoscope	0 (0%)	13 (100%)	NA
KVVL channeled version	22 (100%)	0 (0%)	NA
KVVL non-channeled version	22 (100%)	13 (100%)	NA
<i>Time to intubation (s)</i>			
Macintosh laryngoscope	NA	12.3 (7)	<0.0001 ^c
KVVL channeled version	35 (8.8)	NA	<0.0001 ^c
KVVL non-channeled version	23.5 (5.8)	12.1 (6.2)	<0.0001 ^c

Values are median (IQR [range]), means (standard deviation), or numbers; KVVL, King Vision video laryngoscope; NA, not applicable.

^a Wilcoxon rank sum test.

^b Chi-squared test.

^c Two sample Student's *t* test.

Discussion

It is known that laryngoscopy grade increases with Mallampati class.¹¹ This study demonstrated that despite being associated with a prolonged time to intubation, the KVVL significantly improves the laryngoscopy grade compared with the Macintosh laryngoscope, with a similar success rate of intubation at first attempt and a similar level of desaturation. The main strength of this study is that it evaluated the performance of both laryngoscopes on real patients with variable intubating conditions, and provided a pairwise comparison of their performance.

Two previous studies where paramedics used both laryngoscopes on manikins and cadavers showed markedly improved overall intubation success rate with KVVL over the Macintosh laryngoscope (100% vs. 69.7% and 91.5% vs. 64.9%, respectively).^{7,12} In contrast, this study found similar overall intubation success rates with the Macintosh laryngoscope and the KVVL (94.3% vs. 96.6%). This marked difference may

be due to the other studies using paramedics, while our study used experienced attending laryngoscopists.

Alvis et al. compared KVVL with the McGrath MAC video laryngoscope and reported an overall intubation success rate of 89% using KVVL with the channeled blade.¹³ This comparatively low success rate is surprising, since they studied surgical patients with a predicted easy intubation. In contrast, the patients we could not intubate with the KVVL channeled blade had high Mallampati classes and a history of obstructive sleep apnea, both associated with difficult intubation.¹³

Despite conducting a manikin study, Schoettker et al. reported similar times to ventilation using KVVL.¹⁴ Their median time to ventilation with KVVL was 17.9s (IQR 13.6–28.5), compared to the 21.2s (15.3–29.1) measured in this study. They also reported a similar average exposure to airway management (12 ± 9.9) to that found in this study, which further illustrates that the level of experience of the laryngoscopist is key to the time to intubation.

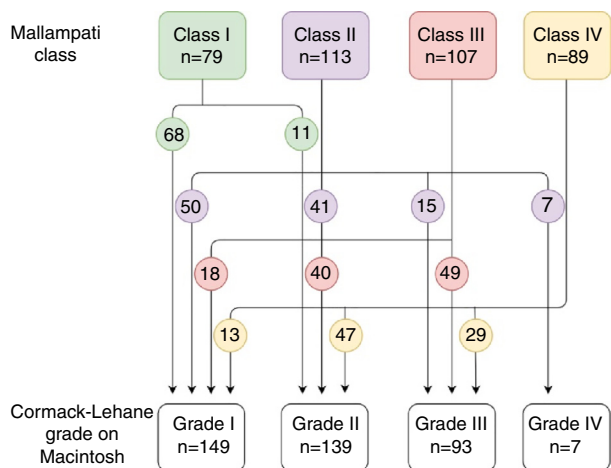


Figure 2 Graphical presentation of Mallampati classes and corresponding Cormack-Lehane laryngoscopy grades obtained with the Macintosh.

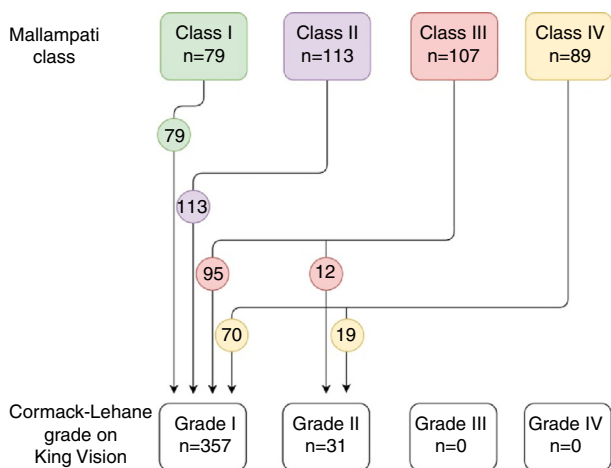


Figure 3 Graphical presentation of Mallampati classes and corresponding Cormack-Lehane laryngoscopy grades obtained with the King Vision.

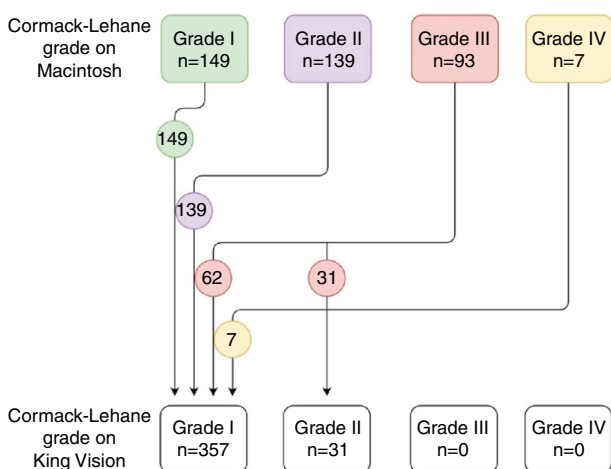


Figure 4 Graphical presentation of improvement in glottic views obtained with the King Vision compared with the Macintosh.

Cortellazzi et al. reported that an anesthesiology trainee, who performed about 50 successful direct laryngoscopies, would need to perform 76 intubations with Glidescope to achieve a 90% probability rate of optimal intubation.¹⁵ Compared to Cortellazzi’s study, this study included only experienced anesthesiologists, therefore we did not observe such a learning curve.

A majority of patients in this study were viewed and intubated in a shorter time with the Macintosh laryngoscope. The channeled KVL blade requires an inter-incisor distance of at least 18 mm, so patients with an inter-incisor distance less than 20 mm were excluded from the study. The large cross-section of the channeled blade appears to be the main disadvantage of KVL, especially in patients with limited mouth opening capacity.¹⁶

Since the channeled blade has a narrow tunnel, we preloaded the endotracheal tube with a preshaped stylet, like similar studies have done before.⁷ Throughout the study, most of our time was spent inserting the channeled blade of the KVL into the mouth and aligning the end of the preloaded endotracheal tube to the trachea. This observation is in agreement with Miceli et al.’s paper, which reported that video laryngoscopes look at the glottic area from an indirect angle, necessitating that the endotracheal tube be prepared with a narrower angle or after viewing the glottis, which can prolong the time to intubation.¹⁰

Although the mean time lost with KVL is not clinically significant (only 1 s during the laryngoscopy and 4 s during the intubation attempts), its channeled blade posed a significant hindrance to its use. In case of 13 patients who could not be intubated with the KVL channeled blade, time to intubation was similar to and even slightly better with the non-channeled KVL blade compared with Macintosh laryngoscope.

Alvis et al., too, reported that the same difficulties were observed while introducing the channeled KVL blade into the mouth and passing the tube through the channeled blade into the glottic opening.¹⁷ The anesthesiologists participating in this study were much more experienced (each one had more than 5000 intubations with the Macintosh laryngoscope, and more than 300 intubations with the KVL) compared to Alvis et al.’s study (anesthesiology residents who had >100 intubations), yet we observed the same difficulties. We are in opinion that the KVL channeled blade is not a helpful instrument.

These data are in strong contrast to the results found by Akihisa et al., who investigated the intubation performance of nurses using KVL (both channeled and non-channeled blades) and Macintosh laryngoscopes in airway manikins.⁶ They gave a limited intubation course, with direct laryngoscopy and KVL, to nurses with no previous experience with tracheal intubation, and found a significantly longer time to intubation and lower success rate with the non-channeled blade. These contrasting findings stress the importance of the expertise of the laryngoscopist in evaluating the efficiency of two airway devices.¹⁸ These findings suggest that the channeled blade may be useful in cases of emergency when experienced anesthesiologists are not available.

Our sample size was calculated according to the data obtained from the first 60 participants, with the difference in intubation success rate being the only variable

considered. This may explain why a clinically insignificant difference in time to intubation resulted in such a huge statistical significance in the other measured outcomes.

Since we sequentially intubated each patient with both laryngoscopes, one might argue that the first laryngoscopy could have given an advantage to the second laryngoscope. In order to minimize this effect, we chose to randomize the order of devices instead of applying each laryngoscope to different patients, since we believe that paired comparison of these laryngoscopes in real patients with varying airway anatomies is important.

There are two recent reviews that compared video laryngoscopy with direct laryngoscopy for adult patients requiring elective tracheal intubation.^{19,20} Both reviews concluded that videolaryngoscopes are useful for intubating patients with difficult airways.

The first review included studies comparing any video laryngoscope with Macintosh laryngoscope.¹⁹ In a total of 64 randomized controlled trials, intubation success rates of video laryngoscopes were similar compared with the Macintosh, however, C-MAC performed better than the Macintosh. The review mentions that the analysis suffers from heterogeneous definitions of experience of the laryngoscopist, and reported time for tracheal intubation. The review defined "experienced operator" as having performed at least 20 intubations with the video laryngoscope; and identified 47 clinical trials where experienced anesthetists performed laryngoscopies. Yet the data about the number of intubations performed by the operators were missing in half of these clinical trials; whereas another half gave symbolic information like "experienced" or "routine user of video laryngoscope". The experience of the operators ranged between 10 and 300, and "manikin-trained" to "expert". Additionally, there is one clinical trial excluding patients with Mallampati scores above 2²¹; and another one excluding patients with Cormack–Lehane grade above 1.²² Although the review's results support our findings, such heterogeneity among the clinical trials show that the results depend on intubating conditions and experience of the laryngoscopist.

The second review included 9 clinical trials including patients with suspected difficult airway and experienced anesthetists.²⁰ Although none of the included clinical trials compared KVL with Macintosh, it is more comparable to this study because it included clinical trials that compared video laryngoscopy with direct laryngoscopy for the same patient. The review supports our conclusion of improved glottic view with video laryngoscopes.

Summary

This prospective study found that experienced anesthesiologists may obtain similar rates of first pass intubation success and airway trauma with KVL and Macintosh laryngoscopes. KVL is inferior to Macintosh laryngoscope in terms of time to best glottic view and time to intubation, but this does not cause clinically significant desaturation. The non-channeled KVL blade may be useful in cases where both laryngoscopes fail to intubate the patient.

Conflicts of interest

The authors declare no conflicts of interest.

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