

## RESPIRATION AND THE AIRWAY

# Double-lumen tube tracheal intubation using a rigid video-stylet: a randomized controlled comparison with the Macintosh laryngoscope

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### Editor's key points

- Video laryngoscopes are useful aids to conventional tracheal intubation.
- However, there are few data on their use with double-lumen endobronchial tubes (DLTs).
- In this study of 400 patients, DLT placement by experienced operators was faster when using an OptiScope® compared with a Macintosh laryngoscope.
- View of the larynx was better and complication rates lower with the OptiScope®.
- The OptiScope® appears to be a useful device for DLT placement.

**Background.** Despite an increasing need, there is limited experience of double-lumen endobronchial tube (DLT) placement using video laryngoscope. We evaluated DLT intubation using an OptiScope, a rigid video-stylet with a malleable tip derived from the Clarus Video System, in comparison with a Macintosh laryngoscope.

**Methods.** After airway evaluation and anaesthetic induction, Cormack and Lehane (C and L) grade was initially assessed in all patients using a Macintosh laryngoscope before tracheal intubation. The trachea was then intubated using either a Macintosh laryngoscope ( $n=200$ ) or an OptiScope® ( $n=200$ ). Success rate, intubation time, number of attempts at intubation, vocal cord view during intubation, need for external manipulation, and the incidences of oral mucosal or dental injury were compared between the two devices.

**Results.** Data were analysed for 397 patients. Intubation time with the OptiScope® was faster [median (inter-quartile range): 15 (12–19) s] than with the Macintosh [18(12–28) s] {mean difference [95% confidence interval (CI)]: 5.5 (3.8–13.2) s,  $P=0.010$ }. The success rate of the first intubation was higher with the OptiScope® than with the Macintosh [80.4% vs 89.9%, odds ratio (95% CI): 2.2 (1.22–3.87),  $P=0.036$ ]. Initial view of the vocal cords was also better, although the final success rate was not different between devices. The need for external laryngeal manipulation, oral mucosal, or dental injury was lower with the OptiScope® compared with the Macintosh laryngoscope (all  $P<0.01$ ).

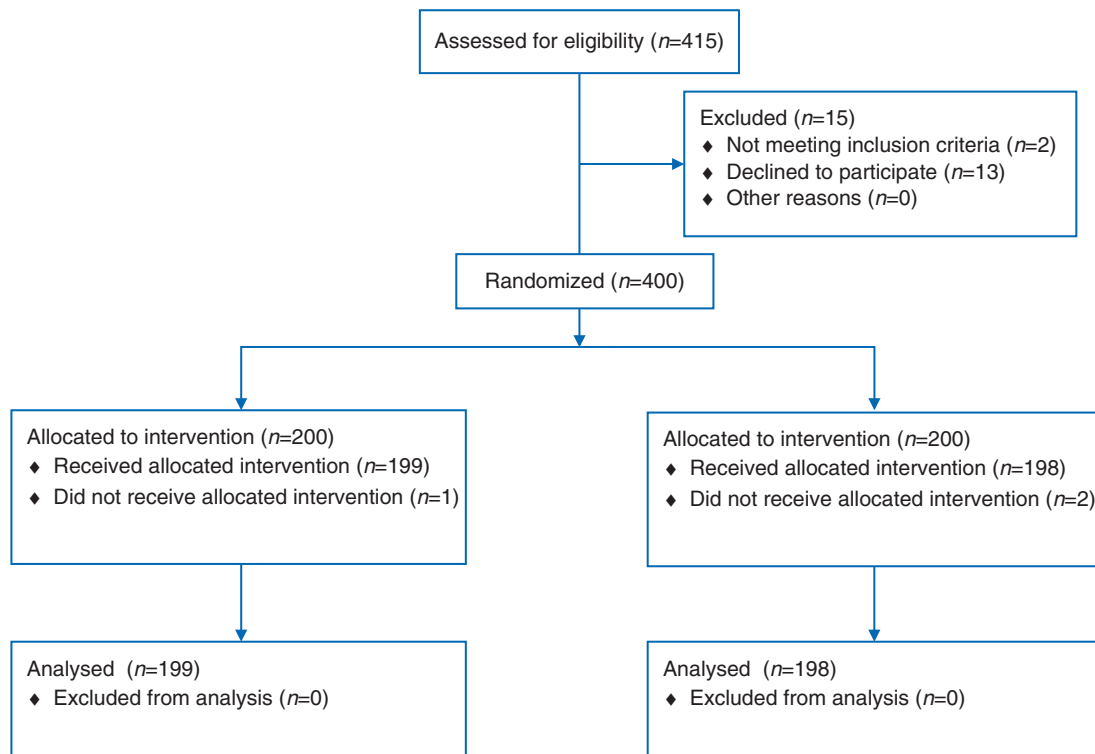
**Conclusions.** The OptiScope® provides faster tracheal intubation and a higher success rate for the first intubation with less trauma and a better vocal cord view than the Macintosh laryngoscope.

**Keywords:** equipment, tubes, double-lumen; laryngoscope; thoracic anaesthesia

Accepted for publication: 25 June 2013

The double-lumen endobronchial tube (DLT) has been widely used for lung separation because it permits easy switching of the ventilated side of the lungs, effective bilateral suctioning, and ancillary continuous positive airway pressure application.<sup>1,2</sup> However, the laryngeal view is frequently obstructed during DLT placement<sup>2–5</sup> because of its large diameter, long length, and fixed shape.<sup>1</sup> Recently, many video laryngoscopes that are primarily for single-lumen tracheal tube insertion have been presented as promising alternatives to the Macintosh laryngoscope.<sup>6</sup> In contrast, there is less extensive experience with the placement of DLTs using video laryngoscope, and its application tends to be only documented in case reports.<sup>3,7–13</sup>

Video laryngoscopes provide a better laryngeal view and do not need airway alignment for tracheal intubation.<sup>14–16</sup> However, the use of video-stylets for DLT placement has been limited by the length and diameter of the intubating stylets developed to date. The narrowest portion of the DLT is the proximal bifurcation region, which is 5 and 7 mm for 35 and 39 Fr Mallinckrodt DLTs, respectively.<sup>9</sup> An optimal intubating stylet for a DLT should have a length of at least 37 cm and a diameter of  $\leq 5$  mm.<sup>9</sup> A video-stylet specifically designed for a DLT (OptiScope®, Pacific Medical, Seoul, Republic of Korea) has been recently introduced. This rigid video-stylet that is derived from the Clarus Video System (Clarus Medical,



**Fig 1** Flow diagram of the study.

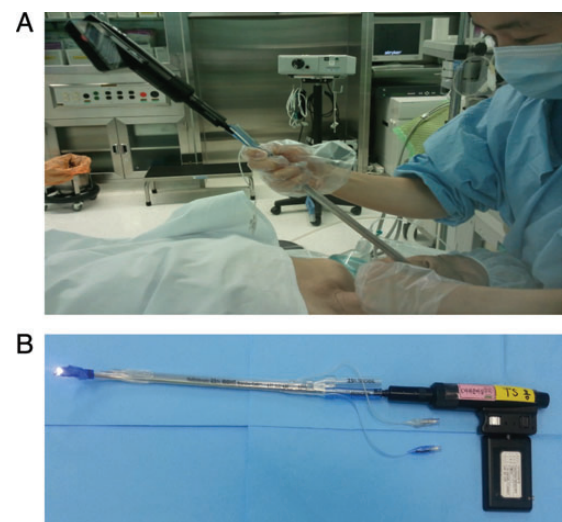
Minneapolis, MN, USA) has a malleable tip, a length of 40.5 cm and an outer diameter of 5 mm, and can accommodate a 35 Fr or larger Mallinckrodt DLT (Fig. 1).

Our aim, in this study, was to compare the efficacy of this new video-stylet designed for a DLT with that of the Macintosh laryngoscope in patients with different grades of vocal cord view as assessed using a Macintosh blade. The main measure that we evaluated was time to intubation; we also compared other intubation conditions between these two devices.

## Methods

This prospective, randomized study was approved by the Institutional Review Board of our hospital and internationally registered for clinical trials (KCT0000382). Written informed consent was obtained from all the participants. Four hundred patients aged 18–80 yr with American Society of Anaesthesiologists physical status I–III who required DLT insertion for thoracic surgery were enrolled in this study from November 2011 to October 2012 (Fig. 2). Patients with increased risk of pulmonary aspiration, planned tracheostomy, or a requirement for rapid sequence induction were excluded from the study.

Patients were randomly allocated into either a Macintosh laryngoscopy group ( $n=200$ ) or an OptiScope® group ( $n=200$ ) using a sealed-envelope technique. A preoperative airway examination of modified Mallampati class, thyromental distance, inter-incisor distance, presence of loose teeth, limitation of neck motion, and neck circumference was performed in all



**Fig 2** (A) Illustration of double-lumen endobronchial tube (DLT) placement using an OptiScope and (B) the OptiScope® preloaded with a 35 Fr right-sided Mallinckrodt DLT.

patients by an observer who was blinded to the study group. The patients did not receive premedication. Induction of anaesthesia was standardized using i.v. lidocaine 40 mg, propofol  $1.5 \text{ mg kg}^{-1}$ , fentanyl  $1 \mu\text{g kg}^{-1}$ , and sevoflurane 4 vol%, and

rocuronium  $1.0 \text{ mg kg}^{-1}$  was used to facilitate tracheal intubation. Three minutes after rocuronium injection and after confirmation of full neuromuscular relaxation with a nerve stimulator, Cormack and Lehane (C and L) grading was performed in all patients using a Macintosh laryngoscope in the sniffing position. Mask ventilation was re-started after initial direct laryngoscopy and the trachea was then intubated using either a Macintosh laryngoscope or an OptiScope<sup>®</sup> according to the pre-allocated group. The OptiScope<sup>®</sup> has the features of a rigid stylet with a distal malleable tip, a movable attached monitor, and a mounted handle (Fig. 2). All tracheal intubations were performed by five anaesthesiologists with more than 4 yr of experience in anaesthesia practice, including more than 100 intubations with the Clarus Video System, which is designed for single-lumen tube placement, and 30 intubations with an OptiScope<sup>®</sup> for a DLT. This level of experience is considered acceptable for clinical competence with other fiberoptic stylets.<sup>16 17</sup> The operators were not blinded to the intubation devices, but were not involved in the collection of data. Left- or right-sided 37 and 35 Fr DLTs (Broncho-Cath<sup>®</sup>, Mallinckrodt Medical Ltd, Athlone, Ireland) were used in male and female patients, respectively. In the Macintosh group, tracheal intubation was performed using a direct Macintosh laryngoscope equipped with a size 3 blade in the sniffing position. In the OptiScope<sup>®</sup> group, tracheal intubation using an OptiScope<sup>®</sup> inserted into the bronchial lumen of a DLT was performed in the neutral head position while the jaw was lifted with the operator's left hand (Fig. 1). The OptiScope<sup>®</sup> was inserted into the mouth, threaded under the epiglottis, and advanced into the vocal cords until the tracheal ring was identified. Once the blue bronchial cuff passed through the vocal cords in the Macintosh group or the distal tip of the DLT passed through the tracheal ring in the OptiScope<sup>®</sup> group, the stylet was removed and the tube was rotated 90° towards the desired side and further advanced until resistance was felt. A fiberoptic bronchoscope was used to verify the correct position of the DLT after intubation. The vocal cord view was re-scored with the C and L grading system during tracheal tube placement using each intubation device. The simultaneous use of other intubation devices to facilitate tracheal intubation was not permitted, but external larynx manipulations were allowed at all times for both devices. Tracheal intubation was considered a failure if it could not be accomplished within 180 s or in three attempts. If intubation failed in this way, the airway was secured with other appropriate methods and this was recorded. The intubation time was defined as the time from the insertion of an intubation device into the mouth until removal of the stylet. If the first intubation attempt failed, the duration of the subsequent attempt was added to the time of the first attempt. The number of attempts and external laryngeal manipulations were recorded. In the data analyses, only the number of attempts and intubation time for successful tracheal intubations were analysed. Blood upon device removal and oral mucosal or dental damage were recorded. Arterial pressures and heart rate were recorded before anaesthetic induction, before intubation, and 1 and 5 min after intubation.

Anaesthesia was maintained during the study period using 2 vol% sevoflurane in 100% oxygen.

## Statistics

The primary aim of this study was to compare intubation times between the two devices. Sample size was based on a preliminary study in which we measured the time for DLT intubation using a Macintosh laryngoscope [mean 18 s and standard deviation (SD) 15 s]. This showed that a sample size of 176 patients per group was required to detect a 25% absolute difference in intubation times, with an assumption of a power of 80% and a 5% risk of a type I error.

Data were tested for normal distribution by the Kolmogorov–Smirnov test. Data were expressed as mean and SD, median and inter-quartile ranges [IQR], or numbers (%). Log transformation was used to transform right-skewed time data to normal. Student's *t*-test (normal distribution) or the Mann–Whitney *U*-test (non-normal distribution) was used for inter-group comparison. Frequencies were analysed with the Pearson  $\chi^2$  or Fisher's exact tests when appropriate. The Bonferroni correction was applied to adjust the probability for multiple comparisons of the frequencies. A *P*-value of <0.05 was considered statistically significant. Statistical analyses were performed using SIGMASTAT 3.05 (Jandel Scientific, San Rafael, CA, USA).

## Results

Three hundred and ninety-seven patients completed this study (Fig. 1). There were no differences in patient characteristics between the two groups (Table 1).

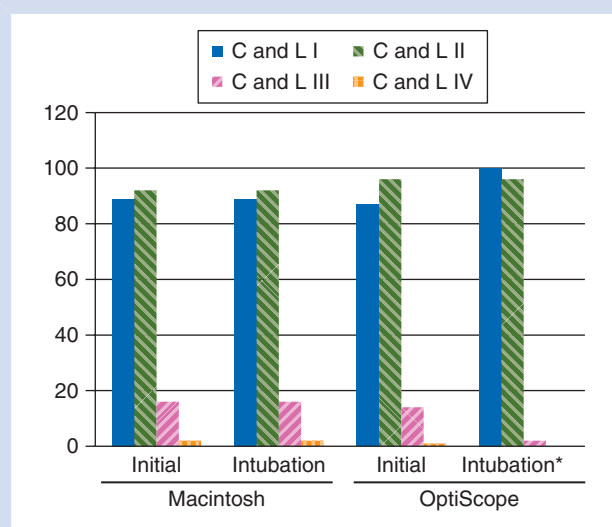
The time to success was lower with the OptiScope<sup>®</sup> than with the Macintosh laryngoscope {median (IQR): 18 (12–28) s for the

**Table 1** Patient characteristic data and airway assessment. Values are mean (SD or range) or number of patients (%). There were no statistical differences between the groups. C and L grade was evaluated using a Macintosh laryngoscope before tracheal intubation in all patients

	Macintosh laryngoscope (n=199)	OptiScope <sup>®</sup> (n=198)
Age (yr)	61 (25–79)	62 (20–78)
Sex (male/female)	150/49	140/58
Height (kg)	162.7 (7.3)	163.1 (8.0)
Weight (cm)	62.5 (9.0)	61.9 (9.3)
Body mass index ( $\text{kg m}^{-2}$ )	23.4 (3.1)	23.2 (2.9)
Mallampati class (1/2/3/4)	67/111/19/2	69/109/19/1
Inter-incisor distance (cm)	4.7 (1.0)	4.9 (0.9)
Thyromental distance (cm)	7.4 (1.3)	7.5 (1.0)
Neck circumference (cm)	36.2 (4.5)	36.1 (3.8)
Limited neck motion (–/+)	191/8	188/10
Loose teeth (–/+)	190/9	187/11
C and L grade (I/II/III/IV)	89/92/16/2	87/96/14/1
Left/right-sided DLT	166/33	163/35

**Table 2** Tracheal intubations. Values are number of patients (%) or median (IQR). The time to success was analysed using Student's *t*-test after log transformation of data because of positive skewedness. Probability of the first intubation attempt was adjusted using the Bonferroni correction

	Macintosh laryngoscope	OptiScope®	P-value
Success/total (n)	192/199 (96.5%)	196/198 (99.0%) OR (95% CI): 3.7 (0.7–17.4)	>0.05
Number of attempts (n)			
1	160 (80.4%)	178 (89.9%) OR (95% CI): 2.2 (1.2–3.9)	0.036
2	29 (14.6%)	16 (8.0%)	
3	3 (1.5%)	2 (1.0%)	
Failed	7	2	
Time to success (s)	18 (12–28)	15 (12–19) mean difference (95% CI): 5.5 (3.8–13.2)	0.010



**Fig 3** C and L grade was initially evaluated by Macintosh laryngoscopy before tracheal intubation in all patients, and then re-evaluated during tracheal intubation using each intubation device. Data are expressed as the number of patients. Initial C and L grade was not different between the device groups ( $P>0.05$ ); however, C and L grade during intubation with the OptiScope® was better than with the Macintosh (\* $P=0.006$  compared with intubation with Macintosh, the probability was adjusted using the Bonferroni correction).

Macintosh vs 15 (12–19) s for the OptiScope, and mean difference [95% confidence interval (CI)]: 5.5 (3.8–13.2 s),  $P=0.010$ , Table 2].

The total success rate of tracheal intubation was not different between the two devices [96.5% for the Macintosh vs 99.0% for OptiScope, odds ratio (OR) (95% CI): 3.6 (0.7–17.4),  $P>0.05$ ]; however, the first intubation success rate was higher with the OptiScope® (89.9%) than with the Macintosh laryngoscope (80.4%) [OR (95% CI): 2.2 (1.2–3.9),  $P=0.036$ , Table 2]. The number of intubation attempts was similar between the two intubation devices ( $P=0.159$ , Table 2). All failed tracheal intubations with either device were successfully

intubated on additional attempts or with the use of a single-lumen tracheal tube and airway exchange catheter.

C and L grade at intubation was better using the OptiScope® than with the Macintosh ( $P=0.006$ , Fig. 3).

External laryngeal manipulation for tracheal intubation was necessary in 32.6% of patients in the Macintosh laryngoscope group and 5.6% in the OptiScope® group [OR (95% CI): 0.12 (0.06–0.24),  $P<0.001$ , Table 3]. The frequency of oral mucosal or dental injury was 21.6% and 1.0% in the Macintosh laryngoscope and OptiScope® groups, respectively [OR (95% CI): 0.04 (0.00–0.16),  $P<0.001$ , Table 3]. One patient in the Macintosh group experienced a newly developed dental injury in association with tracheal intubation. The incidence of entering the opposite side of the bronchus with the DLT was confirmed using a fiberoptic bronchoscope and did not differ between the two devices [4.7% for Macintosh laryngoscope vs 8.3% for OptiScope, OR (95% CI): 1.9 (0.8–4.3),  $P>0.05$ ].

Heart rate and mean arterial pressure increased significantly 1 min after intubation for both intubation devices; however, there was no difference between the groups with regard to haemodynamic responses to tracheal intubation (data not shown).

## Discussion

This study demonstrated that the OptiScope, a rigid video-stylet for DLT, reduced tracheal intubation time and increased the success of the first intubation with the advantages of reducing trauma and providing better laryngeal views in comparison with the Macintosh laryngoscope.

Placing a DLT is more difficult than placing a single-lumen tube in patients with normal or difficult airways because of its large diameter and pre-shaped curvature. The success rate for tracheal intubation varies according to the definition of success and intubation conditions. The rate of success on the first attempt at DLT intubation using video laryngoscopy has been reported to be between 92.8% and 100%, higher than the rate of 67.6–86.7% reported for the Macintosh blade.<sup>18–20</sup> In this study, the first intubation success rate using the



**Table 3** Incidence of oral mucosal or dental injury and external laryngeal manipulations. Values are the number of patients (%)

	Macintosh laryngoscope	OptiScope	P-value
External laryngeal manipulations/total (n)	65/199 (32.6%)	11/198 (5.6%) OR (95% CI): 0.12 (0.06–0.24)	<0.001
Oral mucosal or dental injury/total (n)	43/199 (21.6%)	2/198 (1.0%) OR (95% CI): 0.04 (0.00–0.16)	<0.001

OptiScope® (89.9%) was higher than for the Macintosh laryngoscope (80.4%). However, our success rate for first intubation using a rigid video-stylet seems to be inferior to that reported for video laryngoscopes reported previously.<sup>18–20</sup> Video-stylets seem to require more skill for good performance than video laryngoscopes. A previous report that compared the Shikani optical stylet and the GlideScope in single-lumen tracheal intubation also showed this tendency.<sup>16</sup>

In the present study, the rate of entering the opposite side of the bronchus during intubation was not influenced by the use of either intubation device. For both devices, we removed the intubation stylet after its passage through the vocal cords and then rotated the DLT to the desired direction, thus wrong-sided intubation occurred at similar rates.

In this study, the tracheal intubation time was faster with the OptiScope® than with the Macintosh laryngoscope. Prolonged tracheal intubation is accompanied by a risk of possible airway loss. To facilitate DLT placement in difficult airways, awake fiberoptic bronchoscopy with a single-lumen tracheal tube or DLT or with the use of a video laryngoscope such as the Bullard, WuScope, or GlideScope has been suggested.<sup>1,2</sup> Recently, Hsu and colleagues<sup>19</sup> reported that the use of GlideScope for DLT reduced intubation time, increased the rate of first intubation success, and decreased the incidence of complications compared with a conventional laryngoscope. In addition, Lin and colleagues<sup>20</sup> reported that a new CEL-100 video laryngoscope yielded a higher first intubation success rate, a lower intubation difficulty score, and a better laryngeal view than the Macintosh laryngoscope. A secondary tube exchange technique combined with single-lumen tube intubation using new intubation devices has been also introduced.<sup>1,3</sup> However, replacing a single-lumen tube using an airway exchange catheter with DLT carries a risk of unexpected airway loss, some difficulties, extended intubation time, and a chance of airway trauma.<sup>1</sup> Therefore, diverse modified DLT placement strategies for the direct placement of a DLT have been reported, such as the use of a lighted stylet inserted into a DLT with excision of 2–2.5 cm of both proximal connectors,<sup>9,10</sup> a single longer Trachlight wand consisting of two combined Trachlight wands,<sup>21</sup> and a Trachlight combined with a DLT through a 2 cm longitudinal incision made in the bronchial lumen of a DLT.<sup>22</sup> In addition, a Bonfils intubation fibrescope has been also used with DLTs of size 37 Fr or larger after shortening both proximal connectors to a length of 38.5 cm.<sup>8</sup> However, the routine use of a video-stylet has been not introduced. The video-stylet used in this study is able to fit DLTs of 35 Fr or larger without ancillary modification of the DLT. Although we encountered a little stiffness when inserting the intubating stylet through a 35 Fr DLT, we overcame this by using more lubricant. The OptiScope® is

light in weight: the mounted handle weighs 150 g and the attached monitor weighs 135 g. An increase in the weight of the monitor attached to the left side of the handle disrupts the balance between the two sides, which can potentially disrupt the threading of the stylet towards the midline. We think that the mounted handle and light monitor of the OptiScope® contributes to the easy control of this video-stylet.

A poor laryngeal view is associated with intubation difficulty and laryngeal morbidity, and intubation difficulties can be encountered even with laryngeal views of C and L grade II when intubating a patient with a DLT.<sup>1</sup> It has been reported that the laryngeal view is usually improved with the use of video laryngoscopes.<sup>3,23</sup> A previous study reported that 29.4% (10/34) of patients who underwent DLT placement using a standard laryngoscope had C and L grade III/IV, in contrast to 5.9% (2/34) with the use of a video laryngoscope.<sup>18</sup> We observed an improvement in C and L laryngeal view with the use of the OptiScope: 13 of the 15 patients who had an initial C and L grade of III/IV by Macintosh laryngoscopy before intubation became grade I/II with the use of the video-stylet. The improved laryngeal view could be obtained by moving closer to the vocal cords with the OptiScope. In this study, we routinely performed only the jaw thrust manoeuvre without neck extension for the OptiScope. Considering that thoracic surgery is frequently performed in older patients and that there is an increased tendency for limited neck motion in this aged population, the lack of need for neck extension could be a considerable strength of the video-stylet.

Dental injury is one of the important issues in anaesthetic-related claims,<sup>24–26</sup> and the risk of oro-pharyngeal and dental injury increases with age, intubation difficulty, and cardiothoracic surgery.<sup>27</sup> The video-stylet exerts less traction force around the oro-pharyngeal tissues and less lifting force to the teeth. Our results suggest that the OptiScope® is a relatively atraumatic device and might be a good choice in patients with pre-existing loose teeth. However, it would be necessary to consider the additional financial cost of using a video-stylet before its routine adoption.

This study has some limitations. First, the operators were not blinded to the intubation device used; however, it is difficult to circumvent this problem when evaluating different intubation devices. Secondly, the operators were not equally experienced with both intubation devices. Some training period is required for the skilful use of an intubating stylet, although the skill required is less than that for a flexible fibrescope. The operators had performed more than 30 intubations with the video-stylet and were familiar with the use of a video-stylet to place a single-lumen tube; therefore, we think it is unlikely that the limited operator experience with the video-stylet

influenced performance. Thirdly, we did not evaluate post-operative sore throat and hoarseness because variable surgery duration and type might affect postoperative occurrence. However, it has been suggested that excellent intubating conditions leads to less frequent development of postoperative hoarseness or sore throat.<sup>28</sup> Further studies are needed to validate this issue. Finally, the tube sizes used in this study were smaller than would be used in standard European practice (37 Fr for female, 39 Fr for male) because of the smaller average height of the study patients. However, we do not think that this would influence the findings of this study.

In conclusion, DLT tracheal intubation using an OptiScope<sup>®</sup> was faster and more successful on the first intubation attempt, while allowing a better laryngeal view and causing less trauma than the Macintosh laryngoscope.

## Authors' contributions

M.Y. and H.J.A. designed the study and conducted the study; J.A.K. designed the study, conducted the study, analysed the data, and wrote the manuscript; J.W.C. conducted the study and prepared the manuscript; D.K.K. designed the study and analysed the data; E.A.C. conducted the study and prepared the manuscript.

## Declaration of interest

We purchased both intubation devices. The manufacturer of the OptiScope<sup>®</sup> provided no financial support and had no input into the study design, analysis of the data, or writing of the paper.

## Funding

None.

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Handling editor: J. P. Thompson