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ORIGINAL ARTICLE

A comparison of the Trachway intubating stylet and the Macintosh laryngoscope in tracheal intubation: a manikin study

Kuo-Chuan Hung · Ping-Heng Tan · Victor Chia-Hsiang Lin · Hao-Kuang Wang · Hung-Shu Chen

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Abstract
Purpose The Trachway intubating stylet (Trachway®), when used by experienced anesthesiologists, has been shown to be effective for difficult airway management. We evaluated the efficacy of this intubating stylet for tracheal intubation in a manikin when used by experienced laryngoscopists with little experience using this device.
Methods Thirty-eight nurse anesthesiologists intubated the trachea of a manikin (Laerdal Airway Management Trainer) with a Trachway intubating stylet or a Macintosh laryngoscope in easy and difficult laryngoscopy scenarios. The duration of the intubation attempts, success rates, dental trauma, and ease of use (0 = very easy; 10 = very difficult) were recorded. The primary endpoint was the duration of the successful tracheal intubation attempt in the difficult laryngoscopy scenario. Data are presented as means (SD).
Results Both devices resulted in similar tracheal intubation performance in the easy laryngoscopy scenario. However, the Trachway intubating stylet provided shorter intubation times (20.8 ± 5.6 vs. 25.5 ± 7.3 s; $p = 0.003$) and easier intubations (2.4 ± 1.6 vs. 5.7 ± 1.8; $p < 0.001$) compared with the Macintosh laryngoscope in the difficult laryngoscopy scenario. All tracheal intubations were successful and no dental trauma was observed when using the Trachway intubating stylet.
Conclusion We concluded that the Trachway intubating stylet, when used by novices, is effective in both easy and difficult laryngoscopy scenarios. In difficult laryngoscopy scenarios, this device provided faster, easier, and less traumatic intubation than the Macintosh laryngoscope.

Keywords Tracheal intubation · Manikin · Trachway intubating stylet

K.-C. Hung (✉) · P.-H. Tan · H.-S. Chen
Department of Anesthesiology, E-DA Hospital, I-Shou University, E-Da Road, Jiau-shu Tsuen, Yan-Chau Shiang, Kaohsiung 824, Taiwan, R.O.C
e-mail: ed102605@gmail.com

P.-H. Tan
Department of Biomedical Engineering, E-DA Hospital, I-Shou University, Kaohsiung, Taiwan, R.O.C

V. C.-H. Lin
Department of Urology, E-DA Hospital, I-Shou University, Kaohsiung, Taiwan, R.O.C

V. C.-H. Lin
Department of Healthcare Administration, E-DA Hospital, I-Shou University, Kaohsiung, Taiwan, R.O.C

H.-K. Wang
Department of Neurosurgery, E-DA Hospital, I-Shou University, Kaohsiung, Taiwan, R.O.C

Introduction

Airway management in patients with a limited oral opening or restricted neck mobility is not uncommon in clinical practice, making tracheal intubation one of the most substantial challenges for anesthesiologists. Tracheal intubation with a Macintosh blade often requires the alignment of the oral, pharyngeal, and tracheal axes to view the glottic opening, and this technique may be difficult when used for patients with a limited oral opening, restricted neck mobility, or both. Applying a rigid cervical collar will effectively reduce the oral opening and neck mobility. In such conditions, previous studies reported that the frequency of difficult direct laryngoscopy (Cormack–Lehane

grade 3/4 laryngeal views) [1] may range from 64 to 75 % [2–4]. Difficulties in direct laryngoscopy may result in multiple laryngoscopic and blind intubation attempts, which may increase the risk of injury to the larynx and surrounding tissue. Moreover, the inability to intubate the trachea successfully is a leading cause of anesthetic morbidity and mortality [5]. Therefore, tracheal intubation for patients with a limited oral opening or restricted neck mobility remains a significant area of difficulty for anesthesiologists.

A variety of optical stylets, which incorporate fiberoptic imaging elements in an intubation stylet, are now available for use in clinical practice [6]. These devices can provide a non-line-of-sight view of the airway and they obviate the need to align the oral, pharyngeal, and tracheal axes. The Trachway intubating stylet (Trachway®; Biotronic Instrument Enterprise, Tai Chung, Taiwan, China) (also known as the Clarus Video System) is a reusable, rigid, straight device with a malleable tip (Fig. 1) [7, 8]. The video image can be observed through the adjustable monitor attached to the rechargeable handle. For an experienced user, this new intubating device reportedly provides faster and easier intubations than the Airway Scope (AWS; Pentax, Tokyo, Japan) in patients with cervical collars [9]. As the Macintosh blade remains the most popular intubating device, most anesthesiologists may be unfamiliar with optical stylets. Therefore, the efficacy of the Trachway® in the performance of tracheal intubation by novice personnel should be evaluated. This study evaluated the performance of the Trachway® when used by novices who had little experience with the device, but who had extensive experience with another device.

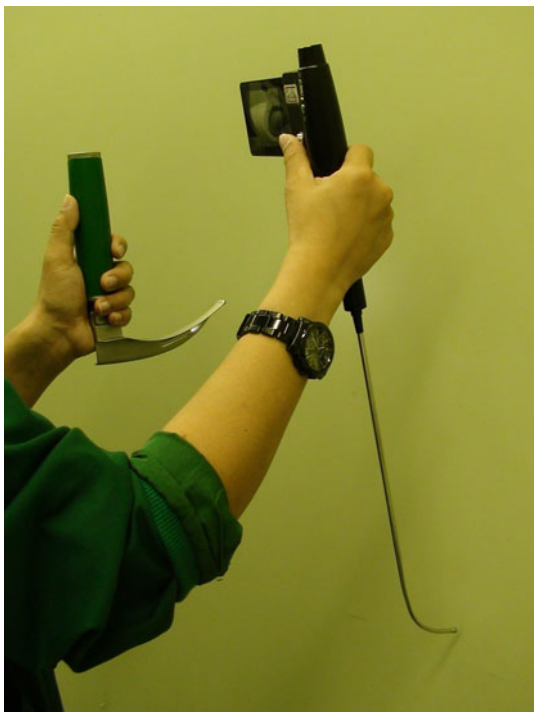

Fig. 1 The Trachway intubating stylet (Trachway®) is a reusable, rigid, straight device with a malleable tip and an adjustable monitor attached to the rechargeable handle. The Trachway® stylet on which the trachea tube is mounted is approximately 32 cm long, with an external diameter of 5.0 mm. At the distal end of the stylet, there is a light source for illumination. The device is held in the dominant hand and inserted into the oral cavity using a midline approach to locate the laryngeal inlet. Handling the device is similar to holding the handle of the Macintosh laryngoscope

Methods

Following ethics committee approval and written informed consent, 38 nurse anesthesiologists with at least 1 year of clinical experience in tracheal intubation with the Macintosh laryngoscope consented to participate in this study. All participants had performed hundreds of intubations using the Macintosh laryngoscope (>100/year) under the supervision of anesthesiologists before participating in the study. Potential participants were excluded if they had ever used any optical stylet for tracheal intubation in clinical practice. Before the study, each participant was given oral and visual instructions on how to properly use the Trachway®. Each participant was then allowed five practice intubations using the Trachway® on a Laerdal Airway Management Trainer (Laerdal, Stavanger, Norway) with an anatomically normal airway, at which stage all participants could successfully intubate the trachea of the manikin with this device. The instructor provided constructive feedback on the intubation process. For the Macintosh laryngoscope, no presentation or demonstration was provided.

All intubations were performed with a size 7.5 cuffed tracheal tube (Portex; Smiths Medical, Hythe, UK). The Trachway® was used according to the manufacturer's instructions. The original curvature (60° curved tip) of the Trachway® was the initial curve used in each intubation attempt. Before the attempt, the Trachway® was preloaded with a tracheal tube. For intubation attempts with the Macintosh blade, a malleable Flexi-Slip stylet (Willy Rusch, Kernen, Germany) was inserted into the tracheal tube, and all participants were allowed to adjust the curvature of the styletted tracheal tube according to their individual experience. Size 3 Macintosh blades were used in the present study [10].

The sequence in which participants used the device was randomized. By tossing a coin, the participant was randomly selected to first use either the Macintosh laryngoscope or the Trachway®, and the same sequence was applied throughout the entire study. The study had a randomized cross-over design. Each participant performed tracheal intubation using each device in the Laerdal Airway

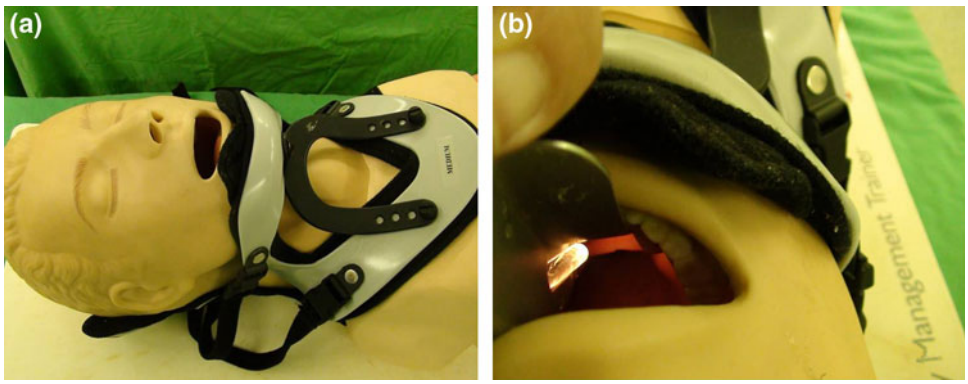

Fig. 2 A rigid cervical immobilization collar was used to reproduce a Cormack and Lehane grade 3 difficult airway in a manikin. In the difficult laryngoscopy scenario, neck movement was impossible and mouth opening was reduced by about 30 % (**a**). On using a size 3 Macintosh blade, only the epiglottis was visible (**b**)

Management Trainer in the following laryngoscopy scenarios: (1) an anatomically normal airway (easy laryngoscopy scenario) and (2) a limited oral opening and cervical immobilization (difficult laryngoscopy scenario). A rigid cervical immobilization collar was used to simulate a difficult airway by reducing the oral opening and limiting neck extension (Fig. 2a). In the difficult laryngoscopy scenario, neck movement was impossible and mouth opening was reduced by about 30 % (maximum interincisor gap was reduced from 3 to 2 cm). On using a size 3 Macintosh blade, only the epiglottis was visible at forced direct laryngoscopy (Cormack–Lehane grade 3 laryngeal view) (Fig. 2b).

The duration of each tracheal intubation attempt (whether successful or not) was recorded and defined as the time taken from the initial insertion of the blade or stylet between the teeth until the tracheal tube was connected to an Ambu bag (Galemed (R), I-Lan, Taiwan) and the lungs were inflated. A failed intubation attempt was defined as an attempt in which the esophagus was intubated or where intubation of the trachea required more than 90 s to perform. If a failed intubation attempt occurred, no more attempts were allowed. The presence of dental trauma was recorded if the Laerdal Airway Trainer produced audible teeth clicks. At the end of each scenario, each participant was asked to score the ease of use with each device, using a rating scale ranging from 0 (very easy) to 10 (very difficult).

The primary endpoint was the duration of the successful tracheal intubation attempt in the difficult laryngoscopy scenario. An additional analysis was performed on the duration of the intubation attempt (whether successful or not), the frequency of successful tracheal intubation, the ease of use of each device, and the frequency of dental trauma in the easy and difficult laryngoscopy scenarios.

One previous study has demonstrated that the intubation time by anesthesiologists in a difficult laryngoscopy scenario (cervical spine immobilization and pharyngeal obstruction) was 24 s [11]. In a pilot study, we estimated the intubation time to be approximately 25 s for nurse anesthesiologists in a difficult laryngoscopy scenario. Assuming a difference of intubation time of 25 % between the two devices in the difficult laryngoscopy scenario ($\beta = 0.2$; $\alpha = 0.05$), we calculated that a total of 34 participants would be required to find a significant difference. To compensate for dropouts, we included 38 participants in the present study.

Data were tested for normal distribution using the Kolmogorov–Smirnov test. Data for the duration of the intubation attempts and the instrument ease of use score were analyzed using Student's *t*-test (normal distribution) or the Mann–Whitney *U*-test (non-normal distribution). Normally distributed data are presented as means (SD); non-normally distributed data are presented as medians (interquartile ranges). Data for the frequency of successful tracheal intubation attempts and dental trauma were analyzed using the χ^2 test or Fisher's exact test as appropriate. These data are presented as raw numbers and frequencies. All statistical operations were performed with SPSS 13.0 (SPSS, Chicago, IL, USA). For all statistical analyses, a p value of <0.05 was considered significant.

Results

Thirty-eight nurse anesthesiologists participated in the study, and their mean clinical anesthetic practice experience was 8.9 ± 6.7 years. In the easy laryngoscopy scenario, all nurse anesthesiologists intubated the trachea of the manikin successfully with both devices. The duration of successful tracheal intubation was similar with both devices (Mackintosh laryngoscope 22.1 ± 5.5 vs. Trachway® 23.6 ± 6.3 s; $p = 0.17$) (Table 1). The frequency of dental trauma and the overall ease of use did not differ significantly between the devices (Table 1). In the difficult laryngoscopy scenario, all participants successfully intubated the trachea of the manikin with the Trachway®, while two participants were unsuccessful with the Macintosh laryngoscope. The difference in success rates was not significant (Trachway® 100 vs. Macintosh laryngoscope 94.7 %;

Table 1 Tracheal intubation with the Macintosh laryngoscope or the Trachway® in easy and difficult laryngoscopy scenarios

	Macintosh ($n = 38$)	Trachway ($n = 38$)	p value
Easy laryngoscopy scenario			
Overall success rate	38 (100 %)	38 (100 %)	1
Duration of intubation attempt (s)[a]	22.1 ± 5.5	23.6 ± 6.3	0.17
Dental trauma (teeth clicks)	3 (7.9 %)	0 (0)	0.08
Overall ease of use[b]	3.4 ± 2	3.3 ± 1.9	0.95
Difficult laryngoscopy scenario			
Overall success rate	36 (94.7 %)	38 (100 %)	0.15
Duration of intubation attempt (s)[a]	25.5 ± 7.3	20.8 ± 5.6	0.003
Dental trauma (teeth clicks)	17 (44.7 %)	0 (0)	<0.001
Overall ease of use[b]	5.7 ± 1.8	2.4 ± 1.6	<0.001

Data are expressed as means ± standard deviation or numbers (%)

[a] Whether successful or not

[b] The ease of use of each device was evaluated using a rating scale ranging from 0 (very easy) to 10 (very difficult)

$p = 0.15$). However, the Trachway® provided faster intubation (20.8 ± 5.6 vs. 25.5 ± 7.3 s; $p = 0.003$), a lower frequency of dental trauma (0 vs. 44.7 %; $p < 0.001$), and was considered to be easier to use compared with the Macintosh laryngoscope (score 2.4 ± 1.6 vs. 5.7 ± 1.8; $p < 0.001$) (Table 1) in the difficult laryngoscopy scenario.

Discussion

Our results demonstrated that the Trachway® and the Macintosh laryngoscope had comparable success rates for tracheal intubation in both the easy and difficult laryngoscopy scenarios. The Trachway® also provided faster, easier, and less traumatic intubations than the Macintosh laryngoscope in the difficult laryngoscopy scenario. These findings suggest that, for even novices with limited experience with the Trachway®, this device can be used effectively to facilitate tracheal intubation, especially in difficult laryngoscopy scenarios.

Tracheal intubation with the Trachway® was considered to be easy by our participants, a finding that might be attributed to its simple operating principle and easy handling. After the tracheal tube is preloaded directly on the stylet, the operator can lift the patient's tongue and jaw forward to create a space for the passage of the optical stylet [12]; handling the device is similar to holding the handle of the Macintosh laryngoscope (Fig. 1.). The stylet is then inserted into the oral cavity, using a midline approach to locate the laryngeal inlet. When the tip of the Trachway® is positioned at the glottis, which can be observed on the adjustable monitor, the tracheal tube is then advanced into the glottis over the stylet under direct vision. The Trachway® has a design similar to that of the Bonfils intubation fiberscope (Bonfils; Karl Storz Endoscopy, Tuttlingen, Germany) [13–15], but the intubating skills required and the handling of the two devices are different. The Bonfils is designed for retromolar placement, and anesthesiologists may need more experience to become familiar with the intubating skills and handling required [16]. In one manikin study, the Bonfils was considered to be more difficult to use than the Macintosh laryngoscope when used by anesthesiologists with little experience with this equipment [16].

In the present study, we found that proficiency with the Trachway® device may be easy to acquire. First, our participants were all successful in intubating the trachea of the manikin after a limited training period. Second, the duration of the intubation attempt in the easy laryngoscopy scenario was 23.6 s and this time decreased to 20.8 s in the difficult laryngoscopy scenario. The overall ease of use of this device also decreased, to a score of 2.4, in the difficult laryngoscopy scenario, from a score of 3.3 in the easy laryngoscopy scenario. A possible explanation for these findings may be that our participants became more confident and familiar with the intubating skills required for the Trachway® after their intubation attempt in the easy laryngoscopy scenario. As the design of this video intubating device does not incorporate a blade, and as the alignment of the oral, pharyngeal, and tracheal axes is not required, the efficacy of the device in facilitating tracheal intubation did not seem to be affected in a difficult laryngoscopy scenario. Therefore, tracheal intubation with the Trachway® became faster and easier even in the difficult laryngoscopy scenario. We suggest that proficiency with the device requires no great skills, although the learning curve may be steep.

To determine the clinical utility of the Trachway® device, we tested nurse anesthesiologists rather than medical students so that we could be certain that our initial

positive findings may be useful for anesthesiologists who have not yet had the opportunity to use this device. However, the similar overall success rates (Trachway® 100 vs. Macintosh laryngoscope 94.7 %, $P = 0.15$) and intubation times (Trachway® 20.8 s vs. Macintosh laryngoscope 25.5 s, $P = 0.003$) with both devices in the difficult laryngoscopy scenario may make some consider this improvement to be not so impressive. One possible explanation for these findings may be that some flaw may exist in our simulated model. For example, we did not reconfirm that the same view (a Cormack–Lehane grade 3 laryngeal view) was obtained at the end of each sequence as at the beginning. Despite the similar overall success rates with both devices, our participants still subjectively rated the Trachway® as easier to use when compared with the more familiar Macintosh laryngoscope. This finding further confirms the clinical utility of the Trachway® device when used by experienced laryngoscopists who have little experience with the equipment.

Airway management with the Trachway® may have some advantages in clinical practice. First, the design of Trachway® does not incorporate bulky blades, which may make it useful in the management of patients with reduced oral openings and obviate the potential for dental trauma. An inter-incisor distance that minimally exceeds the outer diameter of the corresponding tracheal tube is generally adequate for the manipulation of this device. Additionally, the tip of the Trachway® can be positioned below the glottis, and this positioning can minimize the chance of inadvertent tube misplacement into the esophagus and decrease the risk of impingement on the laryngeal structures during tracheal tube advancement. Compared with the Trachway®, there may be some difficulty in advancing the tracheal tube toward the view of the video-monitor with some video laryngoscopes [17].

Flexible fiberoptic tracheal intubation is a useful technique for patients whose tracheas are difficult to intubate [18], but the performance of this technique often requires a considerable amount of training and experience. In addition, this technique may occasionally fail because the tip of the tracheal tube may impinge on the laryngeal structures or migrate into the esophageal inlet during the advancement of the tracheal tube [19, 20]. Unexpected airway injury may be possible in such a condition [21]. Compared with flexible fiberoptic laryngoscopy, railroading of the tracheal tube over the stylet of the Trachway® is more straightforward. Minimal trauma to the airway is one of the advantages claimed for optical stylets [22], and this advantage has also been demonstrated in several clinical studies [9, 22, 23].

Some limitations exist regarding the present study. First, the study did not include a comparison of the other intubation modalities recommended for difficult airway scenarios, such as the Airway Scope. Second, we examined only 2 intubation scenarios. The usefulness of the device should be determined in other situations, such as in the presence of tongue edema or pharyngeal obstruction. Evaluating the utility of the Trachway® in other difficult airway scenarios would have made our finding more credible. Third, this was a manikin study, and it may not adequately mimic clinical conditions. For example, fogging and mucous secretions may obscure the view of the laryngeal anatomy, making tracheal intubation with the Trachway® device more difficult. Lastly, these results may not be applicable to other novices who have little experience in airway management.

In conclusion, even in the hands of novices who have little experience with the equipment, the Trachway® can be used effectively in both easy and difficult laryngoscopy scenarios. Furthermore, in difficult laryngoscopy scenarios, this device can provide faster, easier, and less traumatic intubation than the Macintosh laryngoscope. Nonetheless, additional clinical studies are needed to further delineate the advantages and the limitations of the Trachway® and to better define its place in airway management strategies.

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Conflict of interest The authors have no conflict of interest in regards to the Trachway intubating stylet. The Trachway intubating stylet used in this study was the property of the authors' institution.

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