

RESPIRATION AND THE AIRWAY

Comparison of the Glidescope[®], the Pentax AWS[®], and the Truview EVO2[®] with the Macintosh laryngoscope in experienced anaesthetists: a manikin study

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Background. The Pentax Airwayscope[®], the Glidescope[®], and the Truview EVO2[®] constitute three novel laryngoscopes that facilitate visualization of the vocal cords without alignment of the oral, pharyngeal, and tracheal axes. We compared these devices with the Macintosh laryngoscope in a simulated easy and difficult laryngoscopy.

Methods. Thirty-five experienced anaesthetists were allowed up to three attempts to intubate in each of four laryngoscopy scenarios in a Laerdal[®] SimMan[®] manikin. The time required to perform tracheal intubation, the success rate, number of intubation attempts and of optimization manoeuvres, and the severity of dental compression were recorded.

Results. In the simulated easy laryngoscopy scenarios, there was no difference between the study devices and the Macintosh in success of tracheal intubation. In more difficult tracheal intubation scenarios, the Glidescope[®] and Pentax AWS[®], and to a lesser extent the Truview EVO2[®] laryngoscope demonstrated advantages over the Macintosh laryngoscope including a better view of the glottis, greater success of tracheal intubation, and ease of device use. The Pentax AWS[®] was more successful in achieving tracheal intubation, required less time to successfully perform tracheal intubation, caused less dental trauma, and was considered by the anaesthetists to be easier to use.

Conclusions. The Pentax AWS[®] laryngoscope demonstrated more advantages over the Macintosh laryngoscope than either the Truview EVO2[®] or the Glidescope[®] laryngoscope, when used by experienced anaesthetists in difficult tracheal intubation scenarios.

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Complications arising from difficult or failed tracheal intubation remain a leading cause of anaesthetic morbidity and mortality, notwithstanding recent developments in airway management strategies.¹ Despite a number of factors and combinations of factors having been identified to predict difficult intubation, none is capable of identifying all potentially difficult intubations.² Consequently, many difficult intubations remain unrecognized until after induction of anaesthesia. These issues have stimulated, in part, in the development

of multiple novel laryngoscopes, each of which aims to reduce the difficulty of laryngeal visualization, particularly in the setting of the anticipated or unanticipated difficult airway. The key novel feature of these devices over the Macintosh laryngoscope—which remains the gold standard device—is that they facilitate visualization of the vocal cords without the need to align the oral, pharyngeal, and tracheal axes.

The Truview EVO2[®] (Truphatek International Ltd, Netanya, Israel) laryngoscope blade incorporates an optic

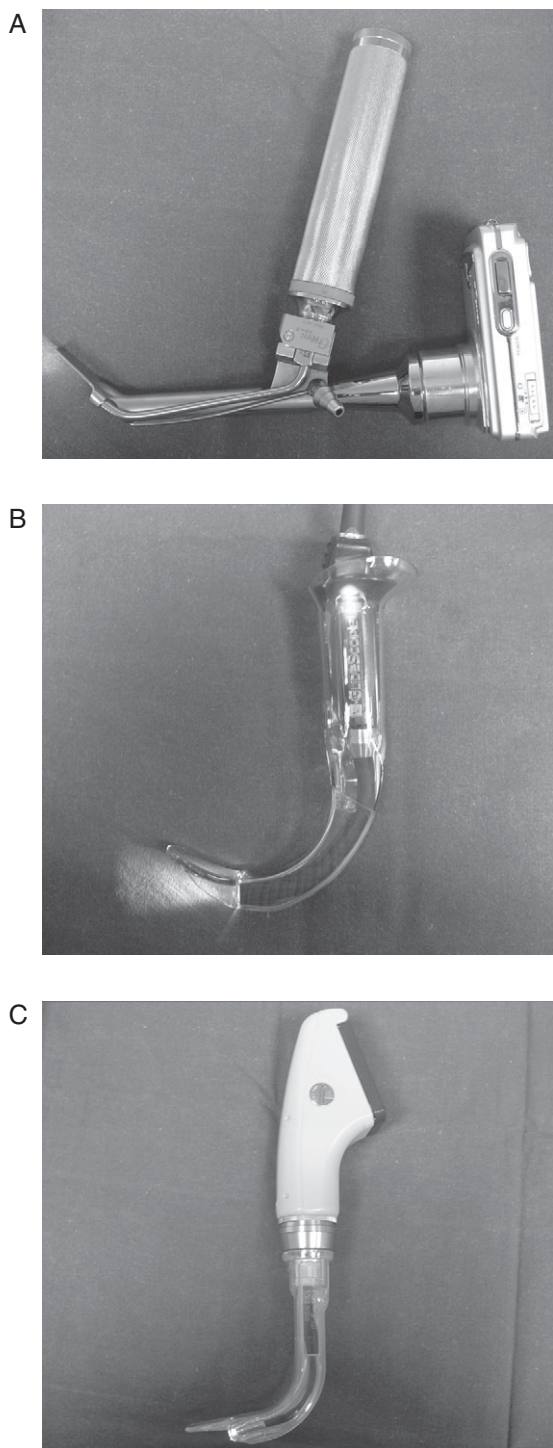


Fig 1 (A) Photograph of the Truview EVO2[®] laryngoscope with camera attachment which clips onto the eyepiece. The attached camera is a Premier 5.2 mega pixel digital camera made specifically for the Truview EVO2[®], with a 5 cm×4 cm LCD screen. (B) Photograph of the Glidescope[®] with single-use blade placed over fiberoptic system. The Glidescope[®] is attached to its standard 8.5 cm×15 cm LCD monitor. (C) Photograph of the Pentax AWS[®] laryngoscope with single-use blade clipped onto the camera system.

side port to its curved blade and provision for O₂ insufflation³ (Fig. 1A). Other recently introduced indirect laryngoscopes include the Glidescope[®] (Saturn Biomedical System

Inc., Burnaby, Canada)⁴ and the Pentax AWS[®] (Pentax Corporation, Tokyo, Japan)⁵ (Fig. 1B and C) devices. Advantages over the Macintosh have been demonstrated for the Truview EVO2[®],³ Glidescope[®],⁴ and for the Pentax AWS[®] in direct comparison studies. However, the relative efficacies of these devices when used by skilled anaesthetists have not been compared in a single study.

The purpose of this study was to evaluate the effectiveness of the Glidescope[®], the Truview EVO2[®], and the Pentax AWS[®] laryngoscopes when used by experienced anaesthetists in anatomically correct manikins. We compared the performance of these devices with that of the Macintosh laryngoscope, in simulated scenarios of varying degrees of difficulty of tracheal intubation.

Methods

After ethical committee approval, and written informed consent, 35 anaesthetists with at least 3 yr of clinical experience consented to participate. Each anaesthetist recruited had to have performed at least 1000 tracheal intubations with the Macintosh laryngoscope. Anaesthetists who had performed more than five intubations with any of the study laryngoscopes were excluded from the study.

The design of the study was a randomized crossover trial. Each anaesthetist was given a standardized 2 min demonstration of the Glidescope[®], the Truview EVO2[®], and the Pentax AWS[®] laryngoscopes by one of the investigators, which included a demonstration of the intubation technique. Each participant was then allowed two practice attempts at tracheal intubation with each device. All intubations were performed with a 7.5 mm cuffed endotracheal tube (ETT). Before each intubation attempt, the ETT cuff was lubricated with Laerdal Airway Lubricant for training manikins (Laerdal Medical AS, Stavanger, Norway) and the cuff was inflated and deflated with a 20 ml BD syringe (BD Drogheda, Ireland). The sequence in which each participant used the devices was randomized, and each anaesthetist used the devices in the same sequence throughout the protocol. Each anaesthetist performed tracheal intubation with each device in a SimMan[®] manikin (Laerdal[®], Kent, UK) in the following laryngoscopy scenarios: (1) normal airway; (2) cervical spine rigidity; (3) tongue oedema; and (4) combined cervical rigidity with tongue oedema.

The primary endpoints were the rate of successful placement of the ETT in the trachea and the duration of the successful tracheal intubation attempt. A failed intubation attempt is defined as an attempt in which the trachea was not intubated, or which required >120 s to perform. The duration of the successful intubation attempt was defined as the time taken from insertion of the blade between the teeth until the position of the ETT was confirmed by the participant to be in the trachea. Where the participant could clearly see the ETT passing through the vocal cords into the trachea, this was sufficient, and the clock stopped. Where the ETT was not clearly visualized by the

participant passing through the vocal cords, the intubation attempt was not considered complete until the ETT was connected to an Ambu[®] bag (Galed[®], I-Lan, Taiwan) and the presence of lung inflation was confirmed. In any case, after each intubation attempt, the final ETT position was verified by an investigator.

Additional endpoints included the duration of the first tracheal intubation attempt, number of intubation attempts, the number of optimization manoeuvres required (readjustment of head position, use of a bougie, and second assistant) to aid tracheal intubation, and the severity of dental trauma. The severity of dental compression was assessed by an investigator based on a grading of the pressure applied on the teeth (none, 0; moderate, 1; and severe, 2) with the laryngoscope during tracheal intubation attempts. At the end of each scenario, each participant scored the degree of difficulty of use of each device on a visual analogue scale (from 0, extremely easy, to 10, extremely difficult). All data, with the exception of the difficulty of device use score, were recorded by one of the two unblinded investigators.

We based our sample size estimation on the duration of the successful tracheal intubation attempt. On the basis of the prior studies,⁶ we projected that the duration of tracheal intubation would be 16 s for the Macintosh laryngoscope, with a standard deviation of 5 s, in the easy laryngoscopy scenario with the Macintosh laryngoscope. We considered that an important change in the duration of tracheal intubation would be a 25% absolute change, that is, a reduction to 10 s or an increase to 18 s. On the basis of these figures, using an $\alpha=0.05$ and $\beta=0.2$, for an experimental design incorporating four equal-sized groups, we estimated that 35 anaesthetists would be required. Further sample size calculations for the difficult tracheal intubation scenarios revealed a requirement for fewer subjects for these scenarios. We therefore aimed to enrol 35 anaesthetists to the study.

Statistical comparisons were restricted to between laryngoscope analyses within each scenario. Comparisons were not made across the different laryngoscopy scenarios. Data for the success of tracheal intubation attempts were analysed using the χ^2 test. Data for duration of the first and the successful intubation attempt, the difficulty of device use score, the number of intubation attempts, the number of optimization manoeuvres, and the severity of dental compression were analysed using the Kruskal–Wallis one-way analysis of variance on ranks with *post hoc* Student–Newman–Keuls tests. Continuous data are presented as mean (standard deviation, sd), ordinal data are presented as median (inter-quartile range), and categorical data are presented as number (%). The α -error level for all analyses was set as $P<0.05$.

Results

Thirty-five anaesthetists, of which 17 were consultants and 18 were trainees, participated in the study. The consultants

had a mean of 20.3 yr of experience, and each had performed an estimated mean of 15 000 tracheal intubations. The trainees had a mean of 9.7 yr of experience and each had performed an estimated mean of 4500 tracheal intubations. No participant had performed <1000 tracheal intubations with the Macintosh laryngoscope. No anaesthetist studied had prior experience of using the Truview EVO2[®] or the Pentax AWS[®] laryngoscopes. Five of the anaesthetists enrolled did have limited clinical experience (maximum of three prior tracheal intubation attempts) with the Glidescope.

Scenario 1: normal airway

All anaesthetists successfully intubated the trachea with each device, with the exception of one anaesthetist who failed to intubate the trachea with Truview EVO2[®] (Table 1). The duration of first tracheal intubation attempt was significantly shorter with the Pentax AWS[®] and significantly longer with the Truview EVO2[®], when compared with the other laryngoscopes studied. The duration of the successful tracheal intubation attempt was significantly longer with the Truview EVO2[®] in comparison with the other laryngoscopes studied (Fig. 2). There were no differences in the number of tracheal intubation attempts required for each device (Table 1). There were no differences in the number of optimization manoeuvres required for each device, with only two anaesthetists requiring optimization manoeuvres with the Macintosh laryngoscope (Table 1).

The severity of dental compression was significantly lower with the Pentax AWS[®] and significantly greater with the Macintosh laryngoscope, compared with the other laryngoscopes studied (Table 1). The anaesthetists rated the Pentax AWS[®] laryngoscope as significantly less difficult to use than the Truview EVO2[®] and the Glidescope[®] laryngoscopes (Fig. 3).

Scenario 2: normal airway with cervical spine rigidity

All anaesthetists successfully intubated the trachea with each device, with the exception of one anaesthetist who failed to intubate the trachea with the Macintosh laryngoscope (Table 1). The duration of the first and the successful tracheal intubation attempts was significantly longer with the Truview EVO2[®] and the Glidescope[®] in comparison with the Macintosh and Pentax AWS[®] laryngoscopes (Fig. 2). There were no differences in the number of tracheal intubation attempts or optimization manoeuvres required for each device (Table 1). The severity of dental compression was significantly lower with the Pentax AWS[®] compared with the other laryngoscopes studied (Table 1). The anaesthetists rated each of the devices as equally difficult to use in this scenario (Fig. 3).

Table 1 Tracheal intubation data for each laryngoscopy scenario. Data are reported as median (inter-quartile range) or as number (%). *Significantly ($P<0.05$) different compared with all other groups. †Significantly ($P<0.05$) different compared with both the Macintosh and the AWS® groups

	Macintosh	Truview EVO2®	Glidescope®	Pentax AWS®
Normal airway				
Overall success rate (%)	35 (100)	34 (97.1)	35 (100)	35 (100)
Duration of first intubation attempt (s), median (inter-quartile range)	10 (7–16)	15 (10–19)*	11 (7–16)	8 (6–12)*
Number of intubation attempts (%)				
1	33 (94.3)	34 (97.1)	34 (97.1)	34 (97.1)
2	2 (5.7)	0 (0)	1 (2.9)	1 (2.9)
3	0 (0)	1 (2.9)	0 (0)	0 (0)
Median (inter-quartile range)	1 (1–1)	1 (1–1)	1 (1–1)	1 (1–1)
Number of optimization manoeuvres (%)				
0	33 (94.3)	35 (100)	35 (100)	35 (100)
1	2 (5.7)	0 (0)	0 (0)	0 (0)
2	0 (0)	0 (0)	0 (0)	0 (0)
Median (inter-quartile range)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
Severity of dental compression (%)				
0	4 (11.4)	9 (25.7)	12 (34.3)	27 (77.1)
1	15 (42.9)	20 (57.1)	19 (54.3)	6 (17.1)
2	16 (45.7)	6 (17.2)	4 (11.4)	2 (5.8)
Median (inter-quartile range)	1 (1–2)*	1 (0–1)†	1 (0–1)†	0 (0–0)*
Cervical spine rigidity				
Overall success rate (%)	34 (97)	35 (100)	35 (100)	35 (100)
Duration of first intubation attempt (s), median (inter-quartile range)	10 (8–18)	17 (12–24)†	15 (11–22)†	11 (8–22)
Number of intubation attempts (%)				
1	33 (94.3)	33 (94.3)	32 (91.4)	32 (91.4)
2	2 (5.7)	2 (5.7)	3 (8.6)	3 (8.6)
3	0 (0)	0 (0)	0 (0)	0 (0)
Median (inter-quartile range)	1 (1–1)	1 (1–1)	1 (1–1)	1 (1–1)
Number of optimization manoeuvres (%)				
0	32 (91.4)	32 (91.4)	35 (100)	35 (100)
1	2 (5.6)	3 (8.6)	0 (0)	0 (0)
2	1 (2.85)	0 (0)	0 (0)	0 (0)
Median (inter-quartile range)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
Severity of dental compression (%)				
0	0 (0)	3 (8.6)	2 (5.7)	10 (28.6)
1	13 (37.1)	14 (40)	18 (51.4)	20 (57.1)
2	22 (62.9)	18 (51.4)	15 (42.9)	5 (14.3)
Median (inter-quartile range)	2 (1–2)	2 (1–2)	1 (1–2)	1 (0–1)*
Tongue oedema				
Overall success rate (%)	3 (8.6)	19 (54.3)	31 (88.6)	35 (100)
Duration of first intubation attempt (s), median (inter-quartile range)	43 (35–67)	45 (28–90)	35 (21–58)	13 (9–20)*
Number of intubation attempts (%)				
1	23 (65.7)	20 (57.1)	23 (65.7)	33 (94.3)
2	9 (25.7)	12 (34.3)	9 (25.7)	1 (2.9)
3	3 (8.6)	3 (8.6)	3 (8.6)	1 (2.8)
Median (inter-quartile range)	1 (1–2)	1 (1–2)	1 (1–2)	1 (1–1)*
Number of optimization manoeuvres (%)				
0	10 (28.6)	26 (74.3)	26 (74.3)	35 (100)
1	21 (60)	4 (11.4)	5 (14.3)	0 (0)
2	4 (11.4)	5 (14.3)	4 (11.4)	0 (0)
Median (inter-quartile range)	1 (0–1)*	0 (0–0.5)†	0 (0–0.75)†	0 (0–0)*
Severity of dental compression (%)				
0	0 (0)	0 (0)	0 (0)	3 (8.6)
1	0 (0)	3 (8.6)	3 (8.6)	21 (60)
2	35 (100)	32 (91.4)	32 (91.4)	11 (31.4)
Median (inter-quartile range)	2 (2–2)	2 (2–2)	2 (2–2)	1 (1–2)*
Combined cervical spine rigidity and tongue oedema scenario				
Overall success rate (%)	4 (11.4)	19 (54.3)	23 (65.7)	32 (91.4)
Duration of first intubation attempt (s), median (inter-quartile range)	49 (34–69)	45 (36–70)	46 (30–56)	19 (13–31)*
Number of intubation attempts (%)				
1	22 (62.9)	24 (68.6)	22 (62.9)	26 (74.3)
2	8 (22.9)	11 (31.4)	8 (22.9)	5 (14.3)
3	5 (14.2)	0 (0)	5 (14.2)	4 (11.4)
Median (inter-quartile range)	1 (1–2)	1 (1–2)	1 (1–2)	1 (1–1.75)
Number of optimization manoeuvres (%)				
0	13 (37.1)	27 (77.1)	26 (74.3)	31 (88.6)
1	19 (54.3)	7 (20)	3 (8.6)	2 (5.7)
2	3 (8.6)	1 (2.9)	6 (17.1)	2 (5.7)
Median (inter-quartile range)	1 (0–1)*	0 (0–0.5)	0 (0–0.75)	0 (0–0)
Severity of dental compression (%)				
0	0 (0)	0 (0)	0 (0)	0 (0)
1	0 (0)	0 (0)	0 (0)	15 (42.9)
2	35 (100)	35 (100)	35 (100)	20 (57.1)
Median (inter-quartile range)	2 (2–2)	2 (2–2)	2 (2–2)	2 (1–2)*

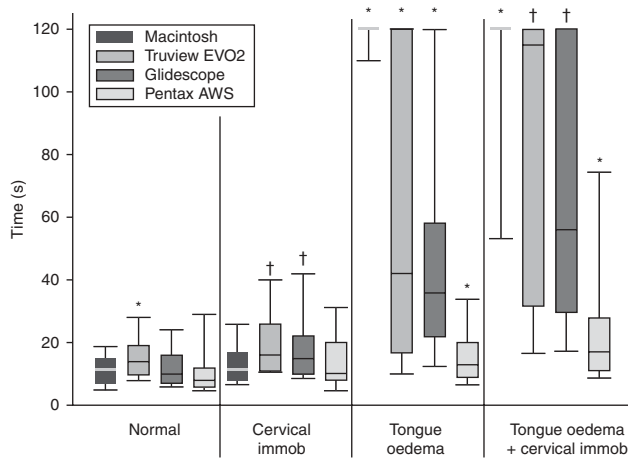


Fig 2 Box plot representing the duration required to successfully intubate the trachea with each device in each scenario tested. The boxes identify the median and inter-quartile range, with the bars representing the 10th and 90th centile. In both the tongue oedema and combined scenario, the median and third quartile values for the Macintosh laryngoscope are the same. The position of the median value for the Macintosh in each scenario is indicated by the grey line. *Significantly different compared with all other groups. †Significantly ($P<0.05$) different compared with both the Macintosh and the AWS® groups. Normal, SimMan® normal airway scenario; Cervical immob, SimMan® cervical spine immobilization scenario; Tongue oedema, SimMan® tongue oedema scenario; Tongue oedema+Cervical immob, SimMan® combined tongue oedema and cervical spine immobilization scenario.

Scenario 3: difficult airway due to tongue oedema

The rate of successful intubation of the trachea was significantly different ($P\leq 0.001$ χ^2) across the groups. The Pentax AWS® laryngoscope was successful in 100% of patients, compared with 78% with the Glidescope, 54% with the Truview, and 9% with the Macintosh, respectively (Table 1). The duration of the first tracheal intubation attempt was significantly shorter with the Pentax AWS® laryngoscope compared with the other devices tested (Table 1). The duration of successful tracheal intubation attempt was significantly shorter with the Pentax AWS® laryngoscope and significantly longer with the Macintosh in comparison with the other laryngoscopes studied (Fig. 2). The number of tracheal intubation attempts and optimization manoeuvres required was significantly lower with the Pentax AWS® laryngoscope compared with the other devices tested (Table 1). In contrast, the number of optimization manoeuvres required with the Macintosh was significantly higher compared with the other devices tested (Table 1). The number of optimization manoeuvres required for the Truview EVO2® and the Glidescope® was less than that required for the Macintosh, but greater than that required for the Pentax AWS® laryngoscope. The severity of dental compression was significantly lower with the Pentax AWS® compared with the other laryngoscopes studied (Table 1). The anaesthetists rated the Pentax AWS® laryngoscope as significantly less difficult to use, and the Macintosh as

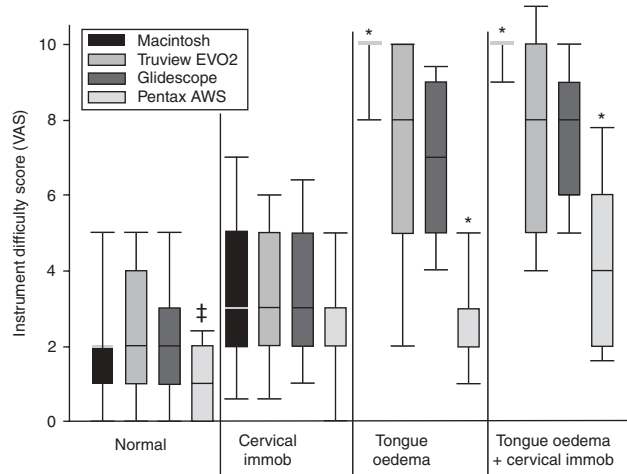


Fig 3 Box plot representing the user rated degree of difficulty of use of each instrument in each scenario tested. The boxes identify the median and inter-quartile range, with the bars representing the 10th and 90th centile. In both the tongue oedema and combined scenarios, the median and third quartile values for the Macintosh laryngoscope are the same. The position of the median value for the Macintosh in each scenario is indicated by the grey line. *Significantly different compared with all other groups. †Significantly ($P<0.05$) different compared to both the Truview® and the Glidescope® groups. Normal, SimMan® normal airway scenario; Cervical immob, SimMan® cervical spine immobilization scenario; Tongue oedema, SimMan® tongue oedema scenario; Tongue oedema+Cervical immob, SimMan® combined tongue oedema and cervical spine immobilization scenario.

significantly more difficult to use, than the other laryngoscopes studied (Fig. 3).

Scenario 4: difficult airway with cervical spine rigidity and tongue oedema

The rate of successful intubation of the trachea was significantly different ($P\leq 0.001$ χ^2) across the groups, and was greatest with the Pentax AWS® laryngoscope and least with the Macintosh laryngoscope (Table 1). The duration of the first tracheal intubation attempt was significantly shorter with the Pentax AWS® laryngoscope compared with the other devices tested (Table 1). The duration of the successful tracheal intubation attempt was significantly shorter with the Pentax AWS® laryngoscope and significantly longer with the Macintosh in comparison with the other laryngoscopes studied (Fig. 2). There were no differences in the number of tracheal intubation attempts required for each device (Table 1). The number of optimization manoeuvres required was significantly higher with the Macintosh laryngoscope compared with the other devices tested (Table 1). The severity of dental compression was significantly lower with the Pentax AWS® compared with the other laryngoscopes studied (Table 1). The anaesthetists rated the Pentax AWS® laryngoscope as significantly less difficult to use, and the Macintosh as significantly more difficult to use, than the other laryngoscopes studied (Fig. 3).

Discussion

Failed tracheal intubation remains a leading cause of anaesthetic morbidity and mortality both within and outside the operating theatre.¹ The adequacy of the laryngeal view obtained is a major factor in determining the difficulty of intubation. Traditional laryngoscopes, such as the Macintosh laryngoscope blade, which was first described in 1943, and remains the standard device for laryngeal visualization, require the alignment of the oral, pharyngeal, and tracheal axes in order to obtain a direct view of the glottis. The Macintosh blade is designed as a device for suspension of the head and displacement of the tongue to allow laryngeal view. In recent years, advances in optical technologies have enabled the development of multiple novel indirect laryngoscopes. A common feature of these devices is that they visualize the laryngeal inlet by indirect mechanisms, obviating the need to align the oral, pharyngeal, and tracheal axes, thereby potentially making laryngeal visualization and subsequent tracheal intubation easier to perform. The Truview EVO2[®] laryngoscope,³ the Glidescope[®],⁴ and the AWS[®] device⁵ are three indirect laryngoscopes each with distinct features likely to confer advantages over the Macintosh laryngoscope. However, the relative efficacies of these devices when used by skilled anaesthetists have not been compared in a single study. We wished to evaluate the relative efficacies of these novel laryngoscopes when used by experienced anaesthetists, in a series of progressively more difficult tracheal intubation scenarios, and to compare these devices with the gold standard Macintosh laryngoscope.

Prior studies have demonstrated that the Glidescope[®] reduces the difficulty of tracheal intubation in direct comparisons with the Macintosh laryngoscope.^{4,7} Our study confirms and extends these findings. Our findings demonstrate that in both the tongue oedema and combined cervical rigidity with tongue oedema scenarios, the Glidescope[®] increased tracheal intubation success rates, reduced the time required to perform tracheal intubation, reduced the need for additional optimization manoeuvres, reduced the potential for dental trauma, and was considered easier to use compared with the Macintosh laryngoscope. The Glidescope[®] performed comparably or more favourably than the Truview EVO2[®]. However, the Glidescope[®] performed less favourably in comparison with the AWS[®] device. In all three difficult laryngoscopy scenarios, the duration of the first and the successful tracheal intubation attempt and the severity of dental compression were increased with the Glidescope compared with the AWS[®] device. In the tongue oedema and the combined cervical rigidity with tongue oedema scenarios, the Glidescope also required more optimization manoeuvres, and was rated as being more difficult to use than the AWS[®] device. The less favourable performance of the Glidescope[®] in comparison with the AWS[®] device appears to be due to difficulties encountered in advancing the tracheal tube towards the view of the video monitor with the Glidescope[®], a finding previously reported by other

investigators.⁴ We utilized a 'hockey-stick' J-curvature of the stylet at the end of the tube, and passed the tube from the lateral side of the patient's mouth, as described by Sun and colleagues,⁴ and found that this approach worked well. Despite this approach, difficulties in advancing the tube appeared to be the principal reason for the increased duration of tracheal intubation in comparison with the AWS[®] device.

The Truview EVO2[®] laryngoscope may possess advantages over the Macintosh laryngoscope in patients at low risk for difficult intubation.^{3,8} In addition, there are case reports that attest to its successful use in patients with difficult airways in whom laryngoscopy with the Macintosh laryngoscope failed.⁹ However, although the Truview EVO2[®] improved Cormack and Lehane grading, it did not reduce intubation time or the ease of tracheal intubation in difficult airway scenarios.¹⁰ Our study demonstrates that in both the tongue oedema and combined cervical rigidity with tongue oedema scenarios, the Truview EVO2[®] did increase tracheal intubation success rates, reduced the time required to successfully perform tracheal intubation, and was considered easier to use compared with the Macintosh laryngoscope. In contrast, the Truview EVO2[®] increased the duration of the first and successful attempts at tracheal intubation compared with the Macintosh in the cervical rigidity scenario. Furthermore, the Truview EVO2[®] did not reduce the need for additional optimization manoeuvres, or reduce the potential for dental trauma compared with the Macintosh laryngoscope. The Truview EVO2[®] was used with its camera attachment on the top of the blade in order to magnify the view of vocal cords via the eyepiece. However, the camera also made the Truview EVO2[®] quite cumbersome to use. Anaesthetists experienced considerable difficulties advancing the tracheal tube towards the view of the digital camera, a finding also previously reported by other investigators.⁸ Overall, the Truview EVO2[®] consistently performed less favourably in comparison with the Glidescope[®] and AWS[®] devices, particularly in the more difficult scenarios.

The Pentax AWS[®] laryngoscope has recently been introduced into clinical practice. Recent clinical studies indicate that this device may have advantages over the Macintosh.⁵ This device also appears to cause less cervical spine movements during tracheal intubation when compared with the Macintosh or McCoy[®] laryngoscopes.¹¹ Our study confirms and extends these findings, and demonstrates that the Pentax AWS[®] performed most favourably of the devices studied. In the more difficult airway scenarios, the Pentax AWS[®] reduced the duration required to perform tracheal intubation, reduced the need for optimization manoeuvres, and possessed the least potential for dental compression compared with the other laryngoscopes studied. The potential for the Pentax AWS[®] laryngoscope to cause less dental compression has been previously reported when this device was used by non-anaesthetist physicians.¹² Our finding that the Pentax AWS[®] reduced tracheal intubation times agrees with some,¹² but not all,¹³ prior studies.

A key difference between the Pentax AWS[®] laryngoscope and the other indirect laryngoscopes studied is the fact that it possesses a side channel through which the ETT is placed before commencement of the intubation attempt. Once the device is inserted, the glottis is visualized and centred on the target mark on the screen, and the ETT is then passed through the glottis. This design feature greatly facilitates the passage of the ETT into the glottis, and is shared with the Airtraq[®] laryngoscope, which has also been demonstrated to perform favourably in comparison with other novel indirect laryngoscopes, in similar studies.⁶ This relative ease of advancing the ETT via the channel through the glottis contrasts markedly with difficulties reported in advancing the tracheal tube towards the view seen in the viewfinder with the Glidescope^{®4} and the Truview EVO2^{®.8}

Four important limitations exist regarding this study. First, this is a manikin rather than a clinical study. However, the simulation of intubation scenarios in anatomically correct manikins has been widely used for similar studies in the past, and has proven a reliable surrogate for the clinical context.¹⁴ These studies have yielded considerable insights into the relative utilities of novel laryngoscopes.^{6, 15, 16} Secondly, the potential for bias exists, as it is impossible to blind the anaesthetist to the device being used. Furthermore, certain measurements used in this study, such as grading of difficulty of device use, are by their nature subjective. However, there was good agreement between subjective indices of difficulty of device use and more objective measures, such as the success of tracheal intubation attempts. Thirdly, this study was carried out in experienced anaesthetists, although they were inexperienced in the use of the novel laryngoscopes. Nevertheless, results may differ in the hands of less experienced users. Finally, the relative efficacies of these devices in comparison with other promising devices such as the Airtraq[®],¹⁷ McCoy[®],¹⁸ McGrath[®],¹⁵ or Bonfils^{®19} have not been determined. Further comparative studies are needed to determine the relative efficacies of these devices.

In conclusion, the Truview EVO2[®], Glidescope[®], and Pentax AWS[®] laryngoscopes each appear to possess advantages over the Macintosh laryngoscope when used by experienced anaesthetists in difficult tracheal intubation scenarios. The Pentax AWS[®] laryngoscope possessed more advantages over the Macintosh laryngoscope than either the Truview EVO2[®] or the Glidescope[®] laryngoscope in these studies.

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