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RESPIRATION AND THE AIRWAY

Pentax-AWS, a new videolaryngoscope, is more effective than the Macintosh laryngoscope for tracheal intubation in patients with restricted neck movements: a randomized comparative study†

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Background. We studied whether laryngoscopy and tracheal intubation were easier when using the Pentax-AWS (Tokyo, Japan), a new videolaryngoscope, than when applying the Macintosh laryngoscope, during manual in-line neck stabilization.

Methods. In 203 anaesthetized patients with manual in-line neck stabilization, we inserted the Pentax-AWS and a Macintosh laryngoscope, in turn, and recorded the view of the glottis and time taken to laryngoscopy. The success rate of tracheal intubation (within 120 s) and time to intubation were also recorded.

Results. The view of the glottis was significantly better with the Pentax-AWS than with the Macintosh laryngoscope ($P<0.001$). For the Macintosh laryngoscope, the view was obscured in 22 of 203 patients (11%) (Grade 3 in 21 patients and Grade 4 in one patient), whereas for the Pentax-AWS, the glottis was always clearly seen (Grade 1). Time taken to see the glottis with the Pentax-AWS [mean (SD): 6.0 (3.1) s] was significantly shorter than with the Macintosh laryngoscope [11.0 (5.0) s] (95% CI for difference: 4–6 s). The success rate of tracheal intubation with the Pentax-AWS (all of 99 patients) was significantly higher than with the Macintosh laryngoscope (93 of 104 patients) ($P=0.001$). Time taken for intubation was similar between the Macintosh laryngoscope [51 (27) s] and the Pentax-AWS [54 (14) s] (95% CI for difference: −9 to 3 s).

Conclusions. In patients with stabilized neck, the Pentax-AWS provided a better view of the glottis and a higher success rate of tracheal intubation, compared with the conventional Macintosh laryngoscope.

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In patients with unstable necks, stabilization of the neck may be required during induction of anaesthesia, by placing the patient's occiput directly on the trolley and holding the head and neck manually (manual in-line stabilization).[1] One major problem with the manual in-line stabilization is that it may make laryngoscopy more difficult, because the angle between the oral and the pharyngeal axes becomes acute at the back of the tongue.[2 3] In addition, fibrescope-aided tracheal intubation and insertion of the laryngeal mask airway may also become difficult during neck stabilization.[4 5]

The videolaryngoscope is one major technological advancement in anaesthesia practice.[6–9] Compared with conventional laryngoscopes, a videolaryngoscope, in theory, provides a better view of the glottis, because the camera eye is within the distance of a few centimetres from the glottis, and because it is unnecessary to align the oral, pharyngeal,

†*Declaration of interest*. Dr Asai has received an honorarium from the manufacturer for giving a lecture, and was loaned the device. The model used by the others was purchased by their departments. No financial support was obtained.

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Fig 1 The Pentax-AWS (Tokyo, Japan). It consists of a disposable transparent blade (PBLADE®), a 12 cm cable with a CCD camera, and a 2.4-in. full-colour LCD monitor display.

Fig 2 The Pentax-AWS, with a tracheal tube attached to the blade. Note that the tip of the tube is captured on the screen even before insertion of the device. The target mark indicates the approximate location of the tube tip when the tube is advanced.

and laryngeal axes (or unnecessary to place the patient's head and neck to the sniffing position) to see the glottis directly from the outside of the patient's mouth.

Pentax-AWS (Tokyo, Japan), a video-laryngoscope, consists of a disposable transparent blade (PBLADE®), a 12 cm cable with a charge-coupled device (CCD) camera, and a 2.4-in. full-colour liquid crystal device (LCD) monitor display (Figs 1 and 2).[10–15] The fibreoptic is inserted into the blade so that the camera eye is approximately 3 cm proximal from the tip of the blade. The device is battery operated. A tracheal tube can be attached to the right side of the blade. There have been anecdotal reports of successful tracheal intubation with the Pentax-AWS in patients in whom tracheal intubation with the Macintosh laryngoscope had failed.[11–14] One study has shown that the Pentax-AWS provided a better view of the glottis than another videolaryngoscope (Fineview, Toray Medical, Tokyo, Japan) did.[15] Therefore, the Pentax-AWS may be useful in patients with restricted neck movement.

The main purpose of our study was to assess whether the Pentax-AWS provided a better view of the glottis and a higher success rate of tracheal intubation than the Macintosh laryngoscope did, in patients whose head and neck were stabilized by the manual in-line method.

Methods

We studied 203 patients (ASA I or II), undergoing elective surgery, in whom tracheal intubation was indicated. Patients were not studied if they had any pathology of the neck, upper respiratory tract or upper alimentary tracts, or they were at risk of pulmonary aspiration of gastric contents. Before operation, the view of the oropharynx was classified according to Mallampati and colleagues[16] and Samsoon and Young.[17] Tracheal intubation was predicted to be difficult, when Mallampati score was Grade 3. The institutional research ethics committee approved the study and written informed consent was obtained from all patients.

In the operating theatre, an electrocardiograph, pulse oximeter, and blood pressure cuff were attached. After preoxygenation of the patient, anaesthesia was induced with propofol, and neuromuscular block was produced with vecuronium 7–10 mg. Several minutes later, neuromuscular block was confirmed using a peripheral nerve stimulator. Anaesthesia was maintained with inhalation of sevoflurane 2%. Nitrous oxide was not used during the study period. The patient's occiput was placed directly on

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the operating table, and an assistant stabilized the patient's head and neck using the manual in-line method. Several different assistants, who took this task in 203 patients, had been taught about the manual in-line method beforehand by anaesthetists. We used the manual in-line method, rather than any other special airway stabilizer, to reflect to ordinary clinical practice. If ventilation via a facemask was judged inadequate, the patient was withdrawn from the study.

In a random cross-over fashion, we compared the Pentax-AWS with a conventional English-type Macintosh laryngoscope (Penlon, Oxford, UK). The order was randomized by tossing a coin. We used a size 3 Macintosh when the patient's height was 175 cm or smaller, and a size 4 when taller than 175 cm. Cuffed tracheal tubes (Portex, Smiths Medical, Kent, UK) of 7.0 mm internal diameter were used in females and tubes of 8.0 mm ID in males, and the use of a gum elastic bougie was allowed when a Macintosh laryngoscope was used. For the Pentax-AWS, a well-lubricated tracheal tube (7.0 mm ID in females; 8.0 mm ID in males) was attached to the right side of the blade before insertion.

Either the Pentax-AWS or the Macintosh laryngoscope was inserted into the mouth, and the view of the glottis was graded using a modified classification reported by Cormack and Lehane (Table 1).[18] We made these modifications, as the tip of the Pentax-AWS blade is inserted towards the glottis and the epiglottis is not expected to be seen. Nevertheless, the grading for the Macintosh laryngoscope with this modified method should be the same for the original grading reported by Cormack and Lehane. No attempt was made to improve the view of the glottis by applying the pressure on the neck. The first laryngoscope was replaced by the other one and the view of the glottis was scored. Laryngoscopy was defined as difficult when the view of the glottis was either Grade 3 or Grade 4. An attempt was made to intubate the trachea using the second laryngoscopy. Only one attempt, up to 2 min (starting from insertion of the second blade), was allowed for tracheal intubation. If tracheal intubation failed, the other laryngoscope was used and tracheal intubation attempted. If tracheal intubation failed after these two attempts, the study was terminated and the airway was managed as a routine clinical practice.

Time taken to laryngoscopy, starting from the tip of the scope passing the gap between upper and lower incisors to exposing the glottis, was recorded. Time to tracheal intubation was also recorded. For the Macintosh laryngoscope, time was taken from a tracheal tube passing the gap between the upper and the lower incisors to confirmation of carbon dioxide waveforms (after tracheal intubation). For the Pentax-AWS, time was taken from touching the tracheal tube (attached to the scope) to confirmation of carbon dioxide waveforms after tracheal intubation.

Table 1 A modified Cormack and Lehane classification[18] for the ease of laryngoscopy

Grade 1	Most of glottis (with or without the epiglottis) is visible
Grade 2	Only the posterior extremity of the glottis is visible
Grade 3	No glottis is visible, but the larynx (such as the epiglottis) can be located
Grade 4	No glottis is visible, and the larynx (such as the epiglottis) cannot be located

Statistical analysis

The main aim of the study was to compare the ease of viewing the glottis between two laryngoscope blades. The second aim was to compare the success rate of tracheal intubation (within 120 s) between the two laryngoscopes. We considered that there would be a clinically meaningful difference if the view of the glottis was difficult (Grade 3 or 4) by using one device and was easy (Grade 1 or 2) by using the other device. A 2×2 table (Grade 1 or 2 *vs* Grade 3 or 4 for the two laryngoscopes) was made and McNemar's test (a test of paired proportions) used to compare the two devices. χ^2 test was used for the success rate of tracheal intubation between the two devices. As additional information, a paired Student's *t*-test was used to compare the time to see the glottis, and an unpaired Student's *t*-test to compare the time for tracheal intubation, between the devices. $P<0.05$ was considered significant. The 95% confidence interval for the mean difference between the two devices was calculated.

As the comparison for the view of the glottis was a cross-over design, we calculated a sample size, for difference in proportions (of difficult laryngoscopy) for the paired sample, using a method described by Connor.[19] The reported incidence of difficult laryngoscopy (Grade 3 or 4) with the Macintosh laryngoscope during manual in-line stabilization was 22–39%,[2 3] and thus we predicted that the incidence would be approximately 30%. We considered that the decrease in the incidence by 15% (from 30%) with the Pentax-AWS would be clinically meaningful. We expected that in up to 5% of cases, laryngoscopy was difficult with the Pentax-AWS but easy with the Macintosh laryngoscope. To detect this difference, with a power of 90% and $P=0.05$, 100 patients would be required. For the success rate of tracheal intubation, we predicted that the proportion would be 90% with the Macintosh laryngoscope and 99% with the Pentax-AWS. To detect this difference, with a power of 80% and $P=0.05$, 200 patients would be required. Therefore, we decided to study 200 patients.

Results

The patients' characteristics are shown in Table 2. Macintosh laryngoscope was used first in 99 patients and Pentax-AWS first in the remaining 104 patients.

The view of the glottis was significantly better with the Pentax-AWS than with the Macintosh laryngoscope

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Table 2 Patients' characteristics [mean (SD) (range)]

Males/females	117/86
ASA physical status (I/II/III)	62/140/1
Age (yr)	57 (16) (18–86)
Height (cm)	160 (9) (130–181)
Weight (kg)	61 (12) (34–105)
Body mass index	24 (3.9) (16–37)
Mallampati score (Grade 1/2/3/4)	154/40/8/1

Table 3 View of the glottis at laryngoscopy with Pentax-AWS and Macintosh blade

Cormack and Lehane classification	1	2	3	4
Macintosh blade	124	57	21	1
Pentax-AWS	203	0	0	0

Table 4 Time to see the glottis (laryngoscopy) and time for tracheal intubation, using a Macintosh laryngoscope or the Pentax-AWS [mean (SD) (range)]

	Laryngoscopy	Tracheal intubation
Macintosh	11.0 (5.0) (7–50)	50.5 (27.0) (20–120)
Pentax-AWS	6.0 (3.1) (6–40)	53.8 (13.7) (25–90)
95% CI for difference	4–6	−9 to 3

Table 5 Success or failure of tracheal intubation using a Macintosh laryngoscope or the Pentax-AWS, within 120 s

	Success	Failure
Macintosh	93 (89%)	11
Pentax-AWS	99 (100%)	0

($P<0.001$) (Table 3). For the Macintosh laryngoscope, the view was obscured in 22 of 203 patients (11%) (Grade 3 in 21 patients and Grade 4 in one patient), whereas for the Pentax-AWS, the glottis was always clearly seen (Grade 1) (Table 3). Time taken to see the glottis with the Pentax-AWS [mean (SD): 6.0 (3.1) s] was significantly shorter than with the Macintosh laryngoscope [11.0 (5.0) s] (95% CI for difference: 4–6 s) (Table 4).

Tracheal intubation using the Macintosh laryngoscope was successful in 93 of 104 patients, whereas intubation using the Pentax-AWS was successful in all of 99 patients (Table 5). There was a significant difference in the success rate of tracheal intubation between the two devices ($P=0.001$). The mean time for tracheal intubation was 51 (27) s with the Macintosh laryngoscope and 54 (14) s with the Pentax-AWS. There was no significant difference between the two devices (95% CI for difference: −9 to 3 s). In the 11 patients in whom tracheal intubation using the Macintosh laryngoscope had failed, intubation was always successful using the Pentax-AWS.

Discussion

We have found that, in patients with stabilized head and neck by the manual in-line method, the Pentax-AWS provided a better view of the glottis and a higher success rate of tracheal intubation (within 120 s), compared with the conventional Macintosh laryngoscope.

Hirabayashi and colleagues[20] found using radiographs that the cervical movement during tracheal intubation is less with the Pentax AWS than with a Macintosh laryngoscope. Another study also has shown that in a manikin with fixed head and neck position, time to intubate the trachea with the Pentax-AWS was significantly shorter than with the Macintosh laryngoscope plus a gum elastic bougie, or than with fibreoptic bronchoscope.[21] These results are consistent with ours. One possible reason for the efficacy of the Pentax-AWS in patients with restricted neck movement is that the device does not require an alignment of the oral, pharyngeal, and laryngeal axes to see the glottis.

Several other videolaryngoscopes, such as Glidescope or TruView, have been shown to be useful in patients with difficult airways.[7 9] One major limitation associated with these videolaryngoscopes is that, even when a clear view of the glottis is obtained, it may often be difficult to intubate the trachea.[9 22] For the Pentax-AWS, a tube can be attached to the blade and the tip of the tube is captured on the videoscreen even before insertion of the device (Figs 1 and 2). Therefore, the location of the tube tip can continuously be confirmed during the entire course of tracheal intubation. In addition, the attached tracheal tube is designed to advance towards the target mark on the screen, and thus intubation should be easy, by manoeuvring the position of the glottis within the target mark (Figs 1 and 2).

Time taken to complete tracheal intubation with the Pentax-AWS was similar to that with the Macintosh laryngoscope, despite the time to see the glottis being significantly shorter. One major possible reason for this is that, it often took more time for the Pentax-AWS to detach the tracheal tube from the blade and remove the blade from the patient's mouth (after tracheal intubation). Time for apnoea can theoretically be reduced by starting manual ventilation before removal of the blade.

In conclusion, we have shown that, in patients with restricted neck movement, the Pentax-AWS is more useful than the conventional Macintosh laryngoscope for tracheal intubation.

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