

RESPIRATION AND THE AIRWAY

Randomized cross-over comparison of cervical-spine motion with the AirWay Scope or Macintosh laryngoscope with in-line stabilization: a video-fluoroscopic study

K. Maruyama^{1*}, T. Yamada², R. Kawakami³ and K. Hara²

¹Department of Anesthesiology, Saitama International Medical Center, Saitama Medical University, 1397-1 Yamane, Hidaka, Saitama 350-1241, Japan. ²Department of Anesthesiology, Iida Municipal Hospital, 438 Yawata, Iida, Nagano 395-8502, Japan. ³Department of Radiology, Aizawa Hospital, 2-5-1 Honjo, Matsumoto, Nagano 390-8510, Japan

*Corresponding author. E-mail: kmaruyam@saitama-med.ac.jp

Background. The AirWay Scope (AWS) is a fiberoptic device that allows for intubation without alignment of the oral, pharyngeal, and tracheal axes. It may be useful for patients with an unstable cervical-spine (C-spine) or when C-spine movement is undesirable. This study was conducted to fluoroscopically evaluate upper C-spine movement during tracheal intubation with the AWS and or the Macintosh laryngoscope with in-line stabilization (ILS).

Methods. Thirteen patients with a normal C-spine and scheduled for elective surgery agreed to simulation of an unstable C-spine and ILS. Two attempts at laryngoscopy were allowed. Laryngoscopy was performed with the Macintosh laryngoscope, then with the AWS, or vice versa. The movement of the upper C-spine during intubation was examined by measuring the angles formed by adjacent vertebrae from the occiput to C4. Time to achievement of intubation was also recorded.

Results. The AWS significantly decreased median movement of the C-spine at the occiput/C1, C1/C2, and C3/C4 concentrations ($P=0.041$, 0.0079 , and 0.0050 , respectively), resulting in a significant decrease in cumulative upper C-spine movement (13.5° with the AWS compared with 30.5° with the Macintosh laryngoscope, $P<0.01$). Intubation time did not differ [23.8 (SD 16.7) s with the AWS; 17.9 (6.4) s with the Macintosh].

Conclusions. In comparison with the use of the Macintosh laryngoscope, the AWS decreased median upper C-spine movement during intubation under ILS in patients with normal C-spine.

Br J Anaesth 2008; **101**: 563–7

Keywords: airway; anaesthetic techniques, laryngoscopy; anatomy, cervical vertebra; complications, neurological; equipment, laryngoscopes

Accepted for publication: May 22, 2008

The incidence of cervical-spine (C-spine) injury in association with blunt trauma is $\sim 2\%$.¹ Patients with C-spine injury occasionally require intubation because of respiratory distress or for airway protection. There may be a risk of spinal cord damage during intubation of patients with possible C-spine injury or an unstable C-spine.² To reduce head extension and decrease C-spine motion, in-line stabilization (ILS) is often performed during intubation in these patients.^{3–5}

The AirWay Scope[®] (AWS) (Pentax, Tokyo, Japan) is a newly developed video laryngoscope, consisting of a

monitor, camera, and disposable introducer (INTLOCK[®]) (Fig. 1).⁶ The main unit contains a charge-coupled device (CCD) camera and a light source with a retractable 2.4-in. liquid-crystal device (LCD) monitor that provides a colour view transmitted from the CCD camera and has a side channel for tracheal tube placement. The structure of the AWS allows for intubation without alignment of the oral, pharyngeal and tracheal axes, and it requires less upper C-spine movement than is required by the Macintosh or McCoy laryngoscope in patients with a normal C-spine.⁷ We have conducted a prospective, randomized, controlled,



Fig 1 Photograph of the AWS[®]. A disposable polycarbonate introducer (INTLOCK[®]) is attached to the main unit, and the tracheal tube is placed in the side channel of the INTLOCK[®].

cross-over study to compare the C-spine movement required for laryngoscopy and intubation with the AWS and the Macintosh laryngoscope under ILS in patients with a normal C-spine.

Methods

The study was approved by the Ethics Committee of Iida Municipal Hospital, and written informed consent was obtained from all participants. We initially enrolled 13 patients, aged 41–68 yr, ASA physical status I–II, who were scheduled to undergo elective surgery requiring general anaesthesia with tracheal intubation. The Mallampati airway score, thyromental and sternomental distances with neck extension, and the degree of mouth opening were evaluated preoperatively as factors predicting difficult intubation. Patients with previous neck surgery or possible pregnancy or patients in whom difficult intubation was anticipated were excluded. Patients without incisor teeth were also excluded due to the effect on expected difficulty of laryngoscopy.

Patients were premedicated with raftidine 20 mg, a histamine-2 receptor blocker, 120 min before induction of anaesthesia. Standard monitoring included electrocardiography, non-invasive arterial pressure measurement and pulse oximetry. Patients received oxygen 6 litre min⁻¹ for several minutes before total i.v. anaesthesia was induced with propofol 2 mg kg⁻¹, ketamine 1 mg kg⁻¹, fentanyl 2 µg kg⁻¹, and vecuronium 0.1 mg kg⁻¹. Before laryngoscopy, patients were placed in the neutral position on a radiolucent, formed rubber head immobilizer (UniversalTM Head Immobilizer, Ferno-Washington, Inc., Wilmington, OH, USA) on the operating table. A block-shaped immobilizer was placed on each side of the head and fixed with Velcro to a base plate, and the forehead and jaw strapped tightly to the head immobilizer. The restraining band across the jaw was loosened minimally to allow intubation, if it

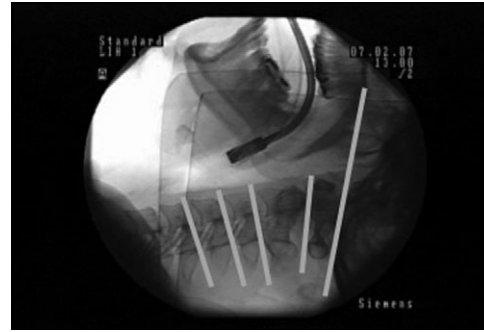


Fig 2 Vertebral reference lines. The reference line for the occiput was the McGregor line, which joins the most dorsal and caudal parts of the occiput to the posterior hard palate. The reference line for the cervical segment C1 was an imaginary line running between the lower cortical margin of the anterior arch and the posterior arch. The reference lines for cervical segments C2–C4 were imaginary lines running between the anterior, inferior margin of the respective vertebral bodies and the lower cortical margin of the respective vertebral bodies and the lower cortical margin of the respective spinous processes. The AWS is *in situ*.

impeded laryngoscopy. Using standard protection against radiation exposure, C-spine movement was observed fluoroscopically and recorded on a videotape with the use of a mobile image intensifier (Siremobile Compact; Siemens, Erlangen, Germany) throughout laryngoscopy until the completion of tracheal intubation. Laryngoscopy was performed twice, once with the AWS and once with the Macintosh laryngoscope (size 3; Welch Allyn, Skaneateles Falls, NY, USA) in random order. For the first device, the patient's mouth was opened by the cross-finger method, and the tip of the tracheal tube was introduced into the glottis. The second device was studied in an identical manner, and intubation was completed with the second device. The duration of laryngoscopy, defined as the time when the Macintosh laryngoscope or the AWS passed the central incisors to the time when the tip of the tracheal tube passed through the glottis, was determined. All laryngoscopies were performed to achieve intubation with minimal glottic exposure by the anaesthetist (T.Y.). The glottic view during laryngoscopy was assessed according to the Cormack–Lehane grading system: Grade 1, full view; Grade 2, only arytenoid cartilages visible; Grade 3, only epiglottis visible; and Grade 4, epiglottis not visible.⁸

We used the McGregor line, which joins the most dorsal edge and caudal portion of the occiput to the posterior hard palate, as a reference line for the occipital bone (Fig. 2). The reference line for C1 was taken as an imaginary line running between the lower cortical margin of the anterior arch and the posterior arch. The reference lines for C2–C4 were imaginary lines running between the anterior, inferior margin of the respective vertebral bodies, and the lower cortical margin of the respective spinous processes. We used appropriate reference lines if the initial anatomical marks were not identified radiographically. Intubation manipulation of the videotape was divided into two time intervals: T1, mouth opening with the cross-

finger manoeuvre to the insertion of the Macintosh laryngoscope or the AWS; and T2, from laryngoscopy until the tip of the tracheal tube passed through the glottis. The recorded video-fluoroscopic images were digitalized with the use of a video-capture card. Maximum movement of the C-spine was determined for each time interval by the radiologist (R.K.), who was blinded to the purpose of the study, and a snapshot was printed out. The movement of the upper C-spine was evaluated by measuring the angles formed by adjacent vertebral reference lines from the occiput to C4 during the two time intervals, and the difference between the neutral position and maximum change in the angles was defined as the change in the angles between adjacent cervical vertebrae. A negative value denoted flexion of the C-spine, and a positive value denoted extension of the C-spine. The sum of the changes in the angles of adjacent vertebrae from the occiput to C4 was taken as cumulative upper C-spine movement.

Statistical analyses

Results are expressed as median (range) values. Median changes in the angle between adjacent cervical vertebrae, cumulative upper C-spine movement and Cormack–Lehane grade obtained for each of the laryngoscopes were compared, and differences were tested statistically by Wilcoxon signed-rank test. The duration of laryngoscopy was tested by paired *t*-test. All statistical analyses were performed with StatView 5.0 (SAS Institute, Inc., Cary, NC, USA). Probability (*P*) values of less than 0.05 were considered statistically significant.

From our preliminary study, we estimated that 11 patients were needed in each group for 80% power to detect a decrease in cumulative upper C-spine movement of 10° with a probability of 0.05 for a type I error.

Table 1 Patient characteristics. Data are shown as absolute numbers of patients, median (range)

Sex (F/M)	7/4
Age (yr)	50 (41–68)
Height (cm)	161 (150–175)
Weight (kg)	55 (41–75)
Mallampati classification (I/II/III/IV)	(10/1/0/0)
Thyromental distance (cm)	10 (9–11)
Sternomental distance (cm)	17 (15–19)
Mouth opening (cm)	5 (4.5–5.5)

Table 2 Median changes in the angle between adjacent cervical vertebrae during T1. T1, Time from mouth opening with the cross-finger manoeuvre to insertion of the Macintosh laryngoscope or the AWS. Data are expressed as median (range). Negative values denote flexion; positive values denote extension. *P* < 0.05 vs AWS group

	AWS	Macintosh	<i>P</i> -value
Occiput–C1 (<i>n</i> =11)	–2.5° (–8.0 to 3.0)	–3.0° (–9.0 to –0.5)	0.088
C1–C2 (<i>n</i> =11)	0.0° (–7.0 to 3.0)	1.0° (–6.0 to 9.0)	0.15
C2–C3 (<i>n</i> =11)	–1.0° (–8.5 to 10.0)	–0.5° (–13.5 to 8.5)	0.055
C3–C4 (<i>n</i> =11)	0.5° (–11.5 to 4.0)	–2.0° (–7.0 to 15.0)	0.42

Results

Two of the 13 patients were excluded from the study because of technical difficulties encountered in positioning the imaging equipment or an inability to measure the angle at the occiput–C1 or C3–C4 vertebrae. Therefore, 11 patients completed the study (Table 1).

There was no statistically significant difference in the median change in angle between adjacent cervical vertebrae during T1 (Table 2). During T2, median changes in angle at the occiput/C1, C1/C2, and C3/C4 concentrations were significantly less with the AWS than with the Macintosh laryngoscope (*P*=0.041, 0.0079, and 0.0050, respectively; Table 3).

During T1, cumulative upper C-spine movement was –1° (–16° to 3°) with the AWS and –5° (–15.5° to 5°) with the Macintosh laryngoscope (Fig. 3). These values did not differ significantly (*P*=0.23). During T2, cumulative upper C-spine movement was 13.5° (–1° to 32°) with the AWS and 30.5° (8.5°–45°) with the Macintosh laryngoscope. Cumulative C-spine movement was significantly decreased with the AWS compared with that with the Macintosh laryngoscope (*P*=0.0076).

The mean duration of laryngoscopy was 24 ± 17 s with the AWS and 16 ± 6 s with the Macintosh laryngoscope.

Table 3 Median changes in the angle between adjacent cervical vertebrae during T2. T2, Time from laryngoscopy to intubation. Data are expressed as median (range). Negative values denote flexion; positive values denote extension. **P* < 0.05 vs AWS group

	AWS	Macintosh	<i>P</i> -value
Occiput–C1 (<i>n</i> =12)	10° (6.0–22.5)	15°* (6.0–21.5)	0.041
C1–C2 (<i>n</i> =13)	4.5° (1.0–8.0)	7.0°* (2.0–11.0)	0.0079
C2–C3 (<i>n</i> =13)	–0.5° (–14.5 to 8.0)	1.5° (–9.0 to 10.5)	0.075
C3–C4 (<i>n</i> =12)	0.5° (–6.0 to 9.5)	3.0°* (–4.5 to 13.5)	0.0050

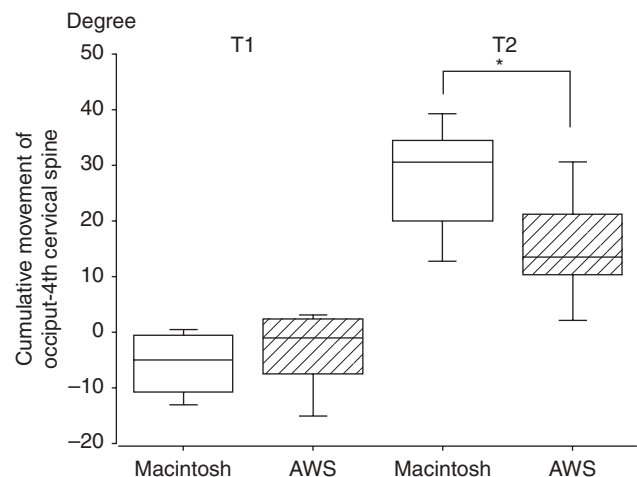


Fig 3 Cumulative movement of the upper cervical spine during T1 and T2. T1, time from mouth opening with the cross-finger manoeuvre to insertion of the AWS or Macintosh laryngoscope. T2, time from laryngoscopy to intubation. **P* < 0.01 vs AWS group.

These values did not differ significantly ($P=0.31$). Assessment of the glottic view during laryngoscopy by Cormack–Lehane grading resulted in a score of 1 with the AWS and a score of 2 with the Macintosh laryngoscope in all patients ($P<0.001$).

Discussion

Various airway management devices to reduce movement of the C-spine under ILS have been evaluated. These include the Bullard laryngoscope, intubating lighted stylet and GlideScope.^{9–10} All of these require some C-spine movement for intubation, but they do reduce C-spine movement compared with intubation with the Macintosh laryngoscope.

In the present study, we found that the AWS produced less upper C-spine movement during laryngoscopy than the Macintosh laryngoscope in patients with ILS. This decrease in C-spine movement suggests that the AWS may be useful for patients in whom the C-spine is unstable or the neck needs to be stabilized during intubation. The angles of movement between adjacent vertebrae were significantly less at the occiput/C1, C1/C2, and C3/C4 concentrations during T2 with the AWS compared with the Macintosh laryngoscope. Thus the AWS may be of use in patients with known C-spine pathology or injury. We recently compared the AWS, Macintosh laryngoscope, and McCoy laryngoscope with respect to C-spine movement during intubation in patients without ILS⁷ and found that cumulative C-spine movement was 32.3° with the Macintosh laryngoscope and 22.3° with the AWS, compared with 30.5° with the Macintosh laryngoscope and 13.5° with the AWS in the present study. This suggests that the effect of minimizing C-spine movement with ILS is more marked with the AWS than the Macintosh laryngoscope. Manipulation with the AWS did not necessarily require C-spine movement; it involved mainly squeezing the soft tissue around the glottis to advance the device into the oral cavity and visualize the glottis. The movement of the C-spine occurred mainly to align the target signal with the glottic opening to introduce the tracheal tube with the AWS. Therefore, we believe that ILS was effective in reducing C-spine movement against the traction force from the elastic soft tissue with use of the AWS. Macintosh laryngoscopy required the alignment of oral, pharyngeal, and tracheal axes to visualize the glottis against ILS, which was necessarily accompanied by C-spine movement.

Although there were no patients with a Cormack–Lehane grade >3 , ILS is known to decrease laryngeal exposure.¹¹ The AWS may provide a better view of the glottis on the LCD monitor and provides visual confirmation of passage of the tracheal tube through the glottis. A good laryngeal view improves the likelihood of successful intubation.¹²

There are several limitations of the present study. First, we did not evaluate C-spine movement during face-mask

ventilation. Displacement of the C-spine occurs with chin lift/jaw thrust during face-mask ventilation, which is more likely to diminish the space available for the cord than direct laryngoscopy.^{11–13} Second, intubation with the Macintosh laryngoscope with ILS is the generally accepted technique for stabilization of the C-spine in patients in whom the C-spine is unstable or in whom C-spine movement is undesirable. However, the severity, site and type of C-spine injury vary, and movement of the C-spine during laryngoscopy is dependant on these factors. Our study was a simulation and care must be taken in extrapolating these results to the clinical airway management of the unstable C-spine patient. The final concern is the intubation procedure with the Macintosh laryngoscope. Laryngoscopy was performed to achieve intubation with minimal glottic exposure. Although the impact on movement of the C-spine had not yet been evaluated, use of the gum elastic bougie with cricoid pressure was reported to facilitate intubation in patients with manual C-spine stabilization.¹⁴ These simple approaches could contribute to additional reduction of C-spine movement during intubation with the Macintosh laryngoscope.

Bias associated with the use of a single-operator protocol may also be of concern. Maximal movement of the C-spine during intubation might be different with other operators. However, intubation technique may also vary in multiple-operator protocols, especially those involving a new device such as the AWS and could result in bias in this type of study. The operator (T.Y.) was familiar with both devices, and his technique was consistent.

In conclusion, upper C-spine movement was significantly decreased during intubation with the AWS compared with that during intubation with the Macintosh laryngoscope in patients with ILS. The AWS may be a good alternative device for intubation during ILS. Studies in patients with unstable C-spine are necessary to further evaluate the AWS.

Funding

The AirWay Scope was provided by Pentax Corporation, Japan.

References

- 1 Crosby ET, Liu A. The adult cervical spine: implications for airway management. *Can J Anaesth* 1990; **37**: 77–93
- 2 Crosby ET. Airway management in adults after cervical spine trauma. *Anesthesiology* 2006; **104**: 1293–318
- 3 Hastings RH, Wood PR. Head extension and laryngeal view during laryngoscopy with cervical spine stabilization maneuvers. *Anesthesiology* 1994; **80**: 825–31
- 4 Majernick TG, Bieniek R, Houston JB, Hughes HG. Cervical spine movement during orotracheal intubation. *Ann Emerg Med* 1986; **15**: 417–20

- 5 Donaldson WF, 3rd, Towers JD, Doctor A, Brand A, Donaldson VP. A methodology to evaluate motion of the unstable spine during intubation techniques. *Spine* 1993; **18**: 2020–3
- 6 Koyama J, Aoyama T, Kusano Y, et al. Description and first clinical application of AirWay Scope for tracheal intubation. *J Neurosurg Anesthesiol* 2006; **18**: 247–50
- 7 Maruyama K, Yamada T, Kawakami R, Kamata T, Yokochi M, Hara K. Upper cervical spine movement during intubation: fluoroscopic comparison of the AirWay Scope, McCoy laryngoscope and Macintosh laryngoscope. *Br J Anaesth* 2008; **100**: 120–4
- 8 Cormack RS, Lehane J. Difficult tracheal intubation in obstetrics. *Anaesthesia* 1984; **39**: 1105–11
- 9 Watts AD, Gelb AW, Bach DB, Pelz DM. Comparison of the Bullard and Macintosh laryngoscopes for endotracheal intubation of patients with a potential cervical spine injury. *Anesthesiology* 1997; **87**: 1335–42
- 10 Turkstra TP, Craen RA, Pelz DM, Gelb AW. Cervical spine motion: a fluoroscopic comparison during intubation with lighted stylet, GlideScope, and Macintosh laryngoscope. *Anesth Analg* 2005; **101**: 910–5
- 11 Brimacombe J, Keller C, Kunzel KH, Gaber O, Boehler M, Puhlinger F. Cervical spine motion during airway management: a cinefluoroscopic study of the posteriorly destabilized third cervical vertebrae in human cadavers. *Anesth Analg* 2000; **91**: 1274–8
- 12 Benumof JL. Difficult laryngoscopy: obtaining the best view. *Can J Anaesth* 1994; **41**: 361–5
- 13 Donaldson WF, 3rd, Heil BV, Donaldson VP, Silvaggio VJ. The effect of airway maneuvers on the unstable C1–C2 segment. A cadaver study. *Spine* 1997; **22**: 1215–8
- 14 Nolan JP, Wilson ME. Orotracheal intubation in patients with potential cervical spine injuries. *Anaesthesia* 1993; **48**: 630–3