



APPARATUS

A comparison of cervical spine movement during laryngoscopy using the Airtraq[®] or Macintosh laryngoscopes★

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Summary

The Airtraq[®] laryngoscope has an oropharyngeal airway-shaped blade that provides a non-line-of-sight view of the glottis. The configuration of the blade should mean that less movement of the cervical spine is required during laryngeal visualisation. We compared the degree of cervical spine movement in laryngoscopy performed using the Airtraq and conventional Macintosh laryngoscope. In 20 patients requiring general anaesthesia and tracheal intubation, we measured cervical spine movement using radiography in the same patient during consecutive procedures using the two laryngoscopes. Although significant movement of the cervical spine from baseline was noted during all procedures ($p < 0.05$), cervical spinal extension with the Airtraq was 29% less than that measured during Macintosh laryngoscopy between the occiput and C4, and 44% less at the C3/C4 motion segment ($p < 0.05$). Anterior deviations of the vertebral bodies from baseline were 32%, 35%, 38% and 40% less at the atlas, C2, C3, and C4 vertebrae, respectively, during Airtraq laryngoscopy than those measured during Macintosh laryngoscopy ($p < 0.01$). Our study demonstrated that laryngoscopy using the Airtraq laryngoscope involves less movement of the cervical spine compared to conventional procedures using a Macintosh laryngoscope.

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Recent advances in optical instrumentation have led to the development of new rigid videolaryngoscopes that provide magnified and high-resolution images of the airway through a nonlinear-view route via an oropharyngeal airway-shaped blade. The resultant indirect laryngeal exposure may require less movement of the cervical spine for adequate imaging than that required by conventional laryngoscopes, which rely on alignment of the oral, pharyngeal, and laryngeal axes.

The Airtraq[®] optical laryngoscope (Prodol, Vizcaya, Spain) is one of the new rigid laryngoscopes [1, 2]. The proximal viewfinder of the scope reflects an image transferred from the distal tip of the blade through a

series of lenses, prisms, and mirrors. The Airtraq has been reported to have advantages compared to the Macintosh laryngoscope in patients with cervical spine immobilisation [3, 4]. Here we assessed such advantages further by directly comparing the extent of cervical spine movement during laryngoscopy using the Airtraq and conventional direct Macintosh laryngoscope.

Material and methods

This study included 20 patients classified as American Society of Anesthesiologists physical status I–II, undergoing general anaesthesia with tracheal intubation for

gynaecological procedures. Exclusion criteria included a history of cervical spine injury, difficult airway, gastro-oesophageal reflux disease, or a body mass index $> 30 \text{ kg.m}^{-2}$. The study protocol was approved by the Human Ethics Committee of Jichi Medical University, and all subjects provided written informed consent.

Patients rested in a supine position on the operating table without a pillow. General anaesthesia was induced using fentanyl $2 \mu\text{g.kg}^{-1}$ and propofol $2\text{--}2.5 \text{ mg.kg}^{-1}$. Muscle relaxation was produced using vecuronium 0.15 mg.kg^{-1} and complete relaxation was monitored using a nerve stimulator (TOF-Watch® SX, Organon, Dublin, Ireland). Anaesthesia was maintained using sevoflurane (expiratory tidal concentration 2.5–3.5%) in oxygen via a bag-mask. Each patient underwent consecutive laryngoscopy procedures using the Airtraq (regular) and a direct laryngoscope fitted with a Macintosh #3 blade; tracheal intubation was completed as part of the second laryngoscopy. The order in which the laryngoscopes were used was randomly assigned at the start of the study. Between laryngoscopies, the patient lungs were ventilated using a bag-mask to avoid hypoxaemia. In all cases, the blade tip of both the Airtraq and Macintosh laryngoscope (Sun Med, Largo, FL, USA) was placed in the vallecula, as recommended by the respective manufacturer. The same anaesthesiologist performed all laryngoscopies.

A mobile X-ray machine (Sirius® 125 MP, Hitachi Medical, Tokyo, Japan) was positioned for a lateral view of the patient's cervical spine throughout the examination period. Before oxygenation, a baseline radiograph was taken with the patient in a neutral head and neck position. During each laryngoscopy, a radiograph was taken when the best view of the larynx was obtained (i.e. three images per patient). A metallic bar was included in all images to serve as a global reference, and a radio-opaque scale was imposed at the midsagittal plane of the patient. All images were exported into the Picture Archiving and Communication System (Synapse, Fujifilm Medical, Tokyo) for examination.

Two radiologists with subspeciality training in musculoskeletal imaging measured vertebral body angles during all laryngoscopies; they were aware of the purpose of the study, but were not familiar with any of the instruments, had no knowledge of head extension during each procedure, and were not aware of the laryngoscope order assigned for each patient. The reference for the occiput (C0, McGregor line) was defined by a line between the posterior margin of the hard palate and the opisthion. The C1 reference line connected the anterior and posterior arches of the atlas. The C2–C4 reference was the tangent through the anterior and posterior basal plates of respective vertebral bodies. We previously described these reference lines radiographically [5]. In this study, the

reference lines were determined by consensus between the two radiologists. The angles between adjacent levels were calculated based on differences between the angles. For example, the C1–C2 angle = (C1 to common line angle) – (C2 to common line angle). Positive angles denote neck extension, and negative angles denote neck flexion. The distance between the occiput and C1 (atlanto-occipital distance, AOD) was measured in mm as the length of a vertical line from C1 to the occiput. The length of a vertical line drawn from the common line to the edge of anterior arch of the atlas was measured in mm; the length of a vertical line drawn from the common line to the anterior, inferior edge of the vertebral body was measured at the C2 vertebra; and, the length of a vertical line drawn from the common line to the anterior, superior edge of the vertebral body was measured at the C3 and C4 vertebrae. The anterior deviation of the spine from baseline was calculated as follows: (length during laryngoscopy) – (length at baseline).

Sample size was calculated based on our previous study [5]; a 20-patient cohort was required to identify a significant difference with $\beta = 0.9$ and $\alpha = 0.05$ in a two-sided test. Data are expressed as mean (SD). Statistical analysis was performed using analyses of variance, followed by the post-hoc test of Student–Newman–Keuls. Student's paired *t*-test was used to analyze the degree of anterior movement of the cervical spine. Significance was accepted at $p < 0.05$.

Results

The patients comprised 20 females, with a mean age of 41 (9) years, weight of 56 (6) kg, and height of 159 (4) cm. The vocal cords were fully visible with both the Airtraq and Macintosh laryngoscope in 19 cases. In the remaining 1 case, the Airtraq visualised the posterior half of the vocal cords, while the Macintosh laryngoscope could only view the posterior extremity of the glottis; both views were sufficient to allow the passage of a tracheal tube.

Table 1 lists the measured angles in the neutral spine position during laryngoscopy with the Airtraq and the Macintosh laryngoscope. Both instruments required significant extension of the cervical spine at all levels compared with baselines ($p < 0.05$). However, extension of the cervical spine was 44% less during Airtraq laryngoscopy than during the Macintosh laryngoscopy at the C3/C4 motion segment ($p < 0.05$, Fig. 1), while no difference was observed at the C0/C1 (19%) and C1/C2 (16%) motion segments. Cervical extension between the occiput and C4 (C0/C4) during the Airtraq procedure was 29% less than that measured using the Macintosh laryngoscope ($p < 0.05$, Fig. 2).

Table 1 Angle between occiput and C1 (C0–C1) and between adjacent vertebral bodies (C1–C2, C2–C3, C3–C4) and between occiput and C4 (C0–C4), atlanto-occipital distance (AOD) in neutral position of the cervical spine (Baseline), during laryngoscopy with the Airtraq and Macintosh laryngoscopes.

	Baseline	Airtraq	Macintosh
C0–C1; °	–8.2 (4.7)	3.1 (4.2)*	5.6 (4.5)*
C1–C2; °	25.1 (7.4)	35.5 (4.5)*	38.7 (4.9)*
C2–C3; °	–0.5 (2.8)	2.0 (3.0)*	3.5 (2.1)*
C3–C4; °	–2.7 (3.4)	2.3 (3.2)*†	6.5 (3.8)*
C0–C4; °	14.8 (5.7)	42.9 (6.3)*†	54.2 (6.1)*
AOD; mm	12.5 (4.2)	9.4 (3.4)*	7.8 (3.3)*

Values are mean (SD). $n = 20$.

* $p < 0.05$, relative to baseline.

† $p < 0.05$, relative to Macintosh laryngoscopy.

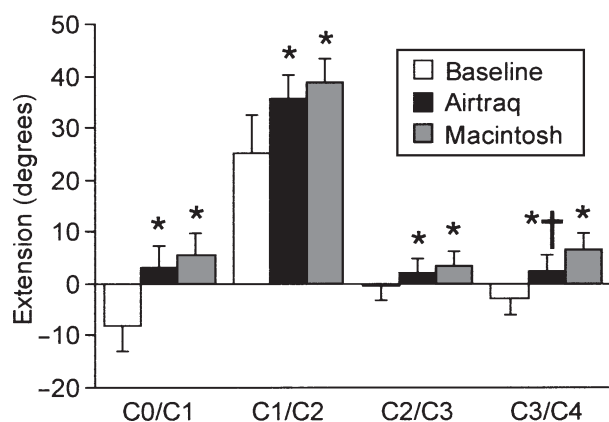


Figure 1 Extension of the cervical spine (angle C0/C1 to C3/C4) during laryngoscopy using the Airtraq® and a Macintosh laryngoscope. Data are mean (SD). * $p < 0.05$, relative to baseline. † $p < 0.05$, relative to Macintosh laryngoscopy levels.

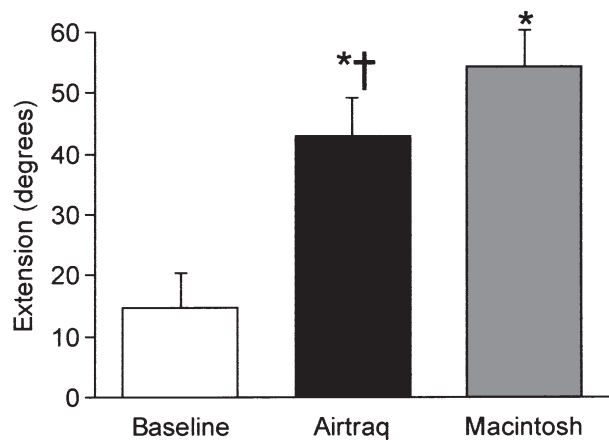


Figure 2 Cervical spinal extension (angle C0/C4) during laryngoscopy using the Airtraq and a Macintosh laryngoscope. Data are mean (SD). * $p < 0.05$, relative to baseline. † $p < 0.05$, relative to Macintosh laryngoscopy levels.

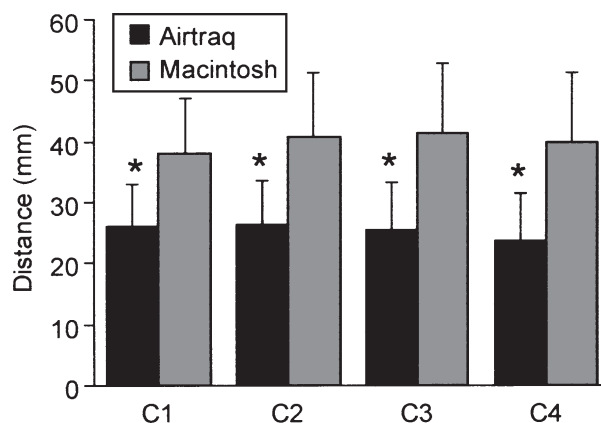


Figure 3 Anterior deviation of the vertebral bodies from baseline during laryngoscopy with the Airtraq and Macintosh laryngoscope at the C1 (atlas) to C4 vertebrae. * $p < 0.01$, relative to Macintosh laryngoscopy.

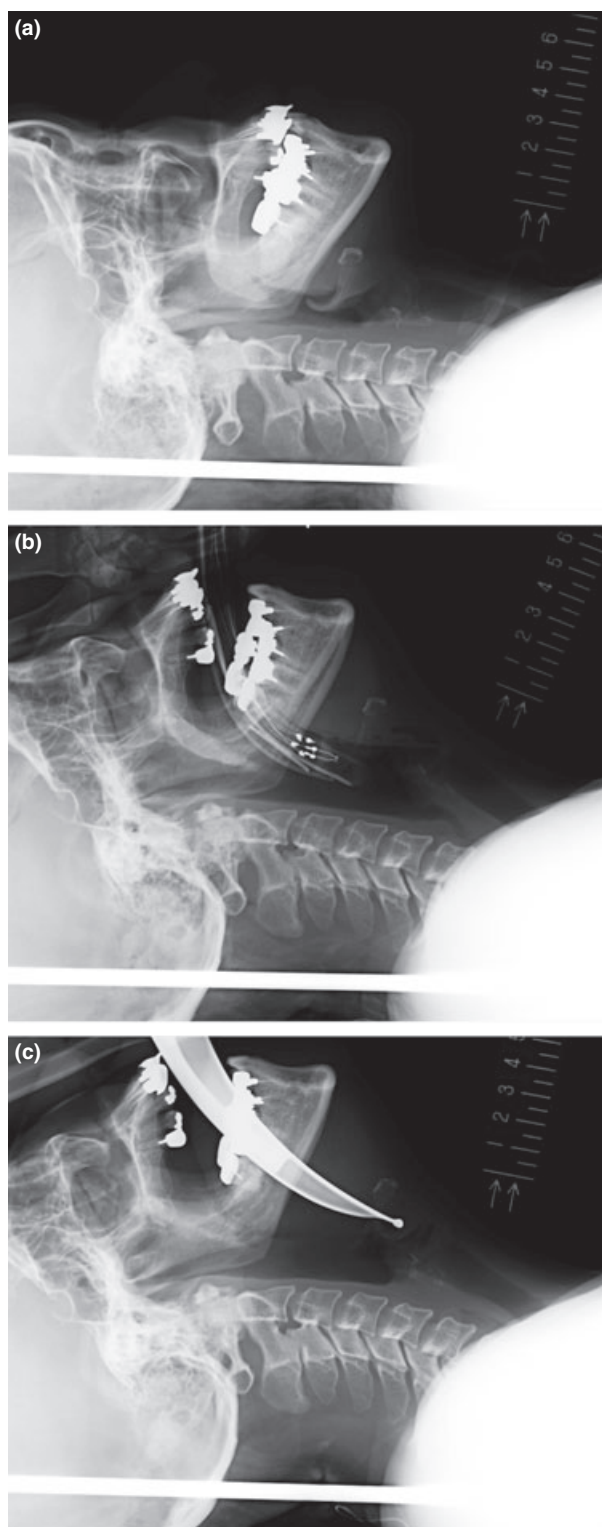
The mean atlanto-occipital distance was significantly reduced during both Airtraq and Macintosh laryngoscopies ($p < 0.05$, Table 1), with no difference between the two techniques.

The anterior movement of the vertebral bodies from baseline was 32%, 35%, 38%, and 40% less using the Airtraq than the Macintosh laryngoscope at the atlas, C2, C3, and C4 vertebrae, respectively ($p < 0.01$, Fig. 3).

Figure 4 shows representative radiographs in a 45-year-old female, demonstrating the position of the cervical spine at baseline and during both laryngoscopy procedures. The Airtraq required less extension of the cervical spine. Deviations of the vertebral body axes from baseline were smaller using the Airtraq than those measured during the Macintosh laryngoscopy (Fig. 5).

Discussion

This study demonstrated radiographically that laryngoscopy using the Airtraq instrumentation involves less movement of the cervical spine than conventional Macintosh laryngoscopy. Cervical spinal extension during the Airtraq laryngoscopy was 29% less than that during the Macintosh laryngoscopy between the occiput and C4, and 44% at the C3/C4 motion segment. Cervical spine extension and anterior deviation from baseline were both less with the Airtraq than the Macintosh laryngoscope. Thus, intubation with the aid of an Airtraq seems more suitable than Macintosh laryngoscopy especially for those patients in whom neck extension is to be avoided.



The Airtraq laryngoscope was designed to follow the anatomy of the oropharyngeal airway structure, with the consequent indirect laryngeal exposure not requiring

Figure 4 Lateral radiographs of a patient showing the position of the cervical spine at baseline with head and neck in a neutral position without pillows (a), during laryngoscopy with the Airtraq (b), or during Macintosh laryngoscopy (c). The measured angle between the occiput and C1 was -4° , -1° , and 4° in (a), (b) and (c), respectively; 25° , 37° , and 37° at the C1/C2 motion segment; and, 12° , 40° , and 48° at the C0/C4 motion segment.

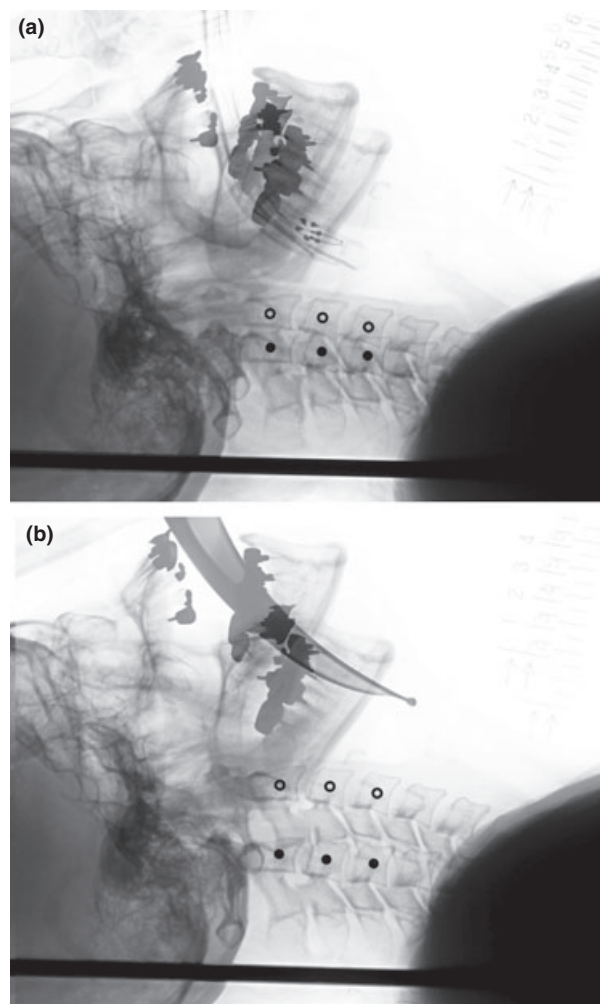


Figure 5 Anterior deviation of the cervical vertebral body axes from baseline during two different laryngoscopic techniques. X-rays taken during the Airtraq (a) and Macintosh laryngoscopies (b) were superimposed over the relevant baseline figure. Negative films were used in these pictures to aid identification. Solid circles: centres of the vertebral bodies (C2, C3 and C4) at baseline, open circles: centres of the vertebral bodies (C2, C3 and C4) during laryngoscopy. Anterior movement at the atlas, C2, C3, and C4 vertebrae during Airtraq laryngoscopy was 18, 18, 17, and 15 mm, respectively, compared to 33, 35, 36, and 35 mm during the Macintosh laryngoscopy.

alignment of the oral, pharyngeal, and tracheal axes. However, a ventral lifting force vector is still necessary to adequately visualise the glottis. The reduced anterior

deviation of the cervical spine during tracheal intubation by the Airtraq in this study compared to the Macintosh laryngoscope indicated that the former was subject to less force during the procedure, and a smaller ventral lifting force vector translates to less pressure on the cervical vertebrae and teeth.

In the current study, the extent of cervical spine extension at the C0/C1 and C1/C2 segments was similar in Airtraq and Macintosh laryngoscopies. Similar findings were reported for another videolaryngoscope by Turkstra et al. [6], who observed 50% less cervical spine movement at the C2/C5 segment using the GlideScope® laryngoscope compared to the Macintosh laryngoscope, while spinal extension was unchanged at the C0/C1 and C1/C2 motion segments. To use both the Airtraq and GlideScope laryngoscopes, the tip of the blade is placed into the vallecula. In contrast, the tip of the blade must be placed under the epiglottis during laryngoscopy with the Airway Scope [7] and Bullard laryngoscope [8, 9]. We reported previously that cervical spine extension during laryngoscopy with the Airway Scope was 37%, 37%, and 68% less than that with the Macintosh laryngoscope at the C0/C1, C1/C2, and C3/C4 motion segments, respectively [5]. Similar findings were also reported in comparisons of the Bullard and Macintosh laryngoscopes at the C0/C1, C1/C2, and C3/C4 motion segments [8, 9]. The position where the tip of the blade is placed to visualise the glottic inlet may therefore be critical to spinal movement at the C0/C1 and C1/C2 motion segments. The ventral forces exerted on the cranial end of the cervical spine may be greater with the Airtraq and GlideScope laryngoscopes than with the Airway Scope and Bullard laryngoscope.

Our study involved static X-ray images rather than fluoroscopy to minimize radiation exposure. Using cinefluoroscopy, Savin et al. [10] reported significant angulation at three stages of the Macintosh laryngoscopy: the laryngoscopy stage (advancement of the blade into the vallecula and application of a ventral lifting force vector), tube stage (radiographically confirmed positioning of the endotracheal tube in the oropharynx), and intubation phase (advancement of the tube through the vocal cords). In their hands, no effort was made to fully expose the glottis. We propose that such intubation conditions, and the inherent difficulty associated with advancing the tube through the vocal cords, would necessitate substantial airway manipulation, and consequently, a significant angulation at the tube and intubation stages. In contrast, the Airtraq has a built-in conduit for placing and inserting the tracheal tube, allowing the tracheal tube to be passed through the glottic inlet as soon as it is aligned in the center of the visual field.

This study aimed to compare the extent of cervical spine movement during laryngoscopy using the Airtraq and conventional Macintosh laryngoscope. We therefore made no attempt to restrict cervical motion during laryngeal exposure. Laryngeal exposure without external stabilisation highlighted the different nature of this new device compared to conventional laryngoscopes. Further investigation is needed to determine cervical spine movement using the Airtraq with manual in-line stabilisation, which manoeuvre minimises cervical spine movement during direct laryngoscopy and intubation [11].

In conclusion, we found in females that laryngoscopy using the Airtraq involves less extension of the cervical spine than conventional laryngoscopy using the Macintosh laryngoscope. We conclude that the reduced movement of the cervical spine during laryngoscopy with the Airtraq makes it a preferred instrument for intubation procedures.

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