

# Endotracheal Intubation in Patients with Cervical Spine Immobilization

## A Comparison of Macintosh and Airtraq Laryngoscopes

Chrisen H. Maharaj, B.Sc., M.B., F.C.A.R.C.S.I., D.P.M.,\* Elma Buckley, M.B., F.C.A.R.C.S.I.,†  
Brian H. Harte, M.B., F.F.A.R.C.S.I.,‡ John G. Laffey, M.D., M.A., B.Sc., F.F.A.R.C.S.I.§

**Background:** The Airtraq laryngoscope (Prodol Ltd., Vizcaya, Spain) is a novel single-use tracheal intubation device. The authors compared ease of intubation with the Airtraq and Macintosh laryngoscopes in patients with cervical spine immobilization in a randomized, controlled clinical trial.

**Methods:** Forty consenting patients presenting for surgery requiring tracheal intubation were randomly assigned to undergo intubation using a Macintosh ( $n = 20$ ) or Airtraq ( $n = 20$ ) laryngoscope. All patients were intubated by one of four anesthesiologists experienced in the use of both laryngoscopes.

**Results:** No significant differences in demographic or airway variables were observed between the groups. All but one patient, in the Macintosh group, were successfully intubated on the first attempt. The Airtraq reduced the duration of intubation attempts (mean  $\pm$  SD:  $13.2 \pm 5.5$  vs.  $20.3 \pm 12.2$  s), the need for additional maneuvers, and the intubation difficulty scale score ( $0.1 \pm 0.5$  vs.  $2.7 \pm 2.5$ ). Tracheal intubation with the Airtraq caused fewer alterations in blood pressure and heart rate.

**Conclusions:** These findings demonstrate the utility of the Airtraq laryngoscope for tracheal intubation in patients with cervical spine immobilization.

FAILURE to adequately immobilize the neck during tracheal intubation in patients with cervical spine injuries can result in a devastating neurologic outcome.<sup>1</sup> A widely used approach to neck immobilization during tracheal intubation is manual in-line axial stabilization (MIAS).<sup>2</sup> Although the evidence base supporting the use of MIAS is limited, this approach has been demonstrated to reduce cervical spine mobility in anatomical studies,<sup>3</sup> and did not result in additional neurologic injury in a case series of oral tracheal intubation in cervical spine-injured adults.<sup>4</sup> However, a key concern is the fact that, with cervical spine immobilization, it is more difficult to visualize the larynx using conventional laryngoscopy.<sup>5–7</sup> Failure to successfully intubate the trachea and secure the airway remains a leading cause of morbidity and

mortality, in the operative<sup>8–10</sup> and emergency settings.<sup>11,12</sup>

The Airtraq (Prodol Ltd., Vizcaya, Spain) is a new indirect laryngoscope that has been developed to facilitate tracheal intubation in patients with normal or difficult airways (fig. 1). As a result of the exaggerated curvature of the blade and an internal arrangement of optical components, a view of the glottis is provided with minimal need for airway optimization maneuvers. The blade of the Airtraq consists of two side-by-side channels. One channel acts as a conduit through which an endotracheal tube (ETT) can be passed, whereas the other channel contains a series of lenses, prisms, and mirrors that transfers the image from the illuminated tip to a proximal viewfinder. A high-quality wide-angle view of the glottis and surrounding structures and the tip of the ETT is provided. The ETT is clearly visualized passing through the vocal cords unlike, for example, the lighted stylet, fiberoptic bronchoscope, or *LMA CTrach*<sup>TM</sup> (The Laryngeal Mask Company, Singapore).<sup>13</sup>

We have previously demonstrated that the Airtraq performs comparably to the Macintosh laryngoscope when used by experienced anesthesiologists in easy laryngoscopy scenarios in the manikin.<sup>14</sup> Of interest, the Airtraq seems to have advantages compared with the Macintosh laryngoscope in simulated difficult intubation scenarios, including reduced cervical spine mobility, in the manikin<sup>14</sup> and when used by both inexperienced<sup>15</sup> and novice<sup>16</sup> users. More recently, we have demonstrated that the Airtraq seems to reduce intubation difficulty in patients at low risk for difficult laryngoscopy.<sup>17</sup>

The purpose of this study was to evaluate the usefulness of this new device for use by experienced anesthesiologists in patients with neck immobilization using MIAS. We hypothesized that, in comparison with the Macintosh, the Airtraq would be associated with lower laryngoscopy times, lower intubation difficulty scale (IDS) scores, and less hemodynamic stimulation after intubation.

## Materials and Methods

After obtaining approval by the Galway University Hospitals Research Ethics Committee (Galway, Ireland) and written informed patient consent, we studied 40 patients with American Society of Anesthesiologists physical status I–III, aged 18 yr or older, scheduled to undergo

\* Research Fellow in Anaesthesia, § Professor of Anaesthesia and Consultant Anaesthetist, Department of Anaesthesia, University College Hospital, Galway, Ireland; Department of Anaesthesia, Clinical Sciences Institute, National University of Ireland. † Specialist Registrar in Anaesthesia, ‡ Consultant Anaesthetist, Department of Anaesthesia, University College Hospital, Galway.

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Address correspondence to Dr. Laffey: Department of Anaesthesia, Clinical Sciences Institute, National University of Ireland, Galway, Ireland. john.laffey@nuigalway.ie. Information on purchasing reprints may be found at [www.anesthesiology.org](http://www.anesthesiology.org) or on the masthead page at the beginning of this issue. ANESTHESIOLOGY's articles are made freely accessible to all readers, for personal use only, 6 months from the cover date of the issue.



**Fig. 1.** Photograph of the Airtraq laryngoscope with an endotracheal tube in place in the side channel.

surgical procedures necessitating tracheal intubation, in a randomized, single-blind, controlled clinical trial. Patients were excluded if risk factors for gastric aspiration and/or difficult intubation (Mallampati class III or IV, thyromental distance less than 6 cm, interincisor distance less than 4.0 cm) were present, or where there was a history of relevant drug allergy. All data were collected by an independent unblinded observer.

Patients were randomly assigned to two groups by sealed envelopes, and patients were blinded to their group assignment. All patients received a standardized general anesthetic. Standard monitoring, including electrocardiography, noninvasive blood pressure, oxygen saturation measured by pulse oximetry, end-tidal carbon dioxide, and volatile anesthetic levels, were used in all patients. Before induction of anesthesia, all patients were given fentanyl (1–1.5  $\mu\text{g/kg}$ ) intravenously. A sleep dose of propofol (2–3  $\text{mg/kg}$ ) was titrated to induce anesthesia. After induction of anesthesia, all patients were manually ventilated with sevoflurane (2.0–2.5%) in oxygen and nitrous oxide, and atracurium (0.35  $\text{mg/kg}$ ) was administered. After the onset of neuromuscular

blockade, the pillow was removed, and the neck was immobilized using MIAS applied by an experienced individual holding the sides of the neck and the mastoid processes, thus preventing flexion/extension or rotational movement of the head and neck.

The trachea was then intubated by one of four anesthesiologists (C.H.M., E.B., B.H.H., J.G.L.) experienced in the use of both laryngoscopes. In patients randomly assigned to undergo intubation with the Airtraq, the blade was inserted into the mouth in the midline, over the center of the tongue (fig. 2A). After the device was passed over the back of the tongue, the view from the viewfinder was used to position the tip in the vallecula (fig. 2B). The view of the glottis could then be optimized by lifting the epiglottis by elevating the blade into the vallecula (fig. 2C). When the view of the glottis had been optimized, the ETT was passed through the vocal cords and held in place, and the device was removed.

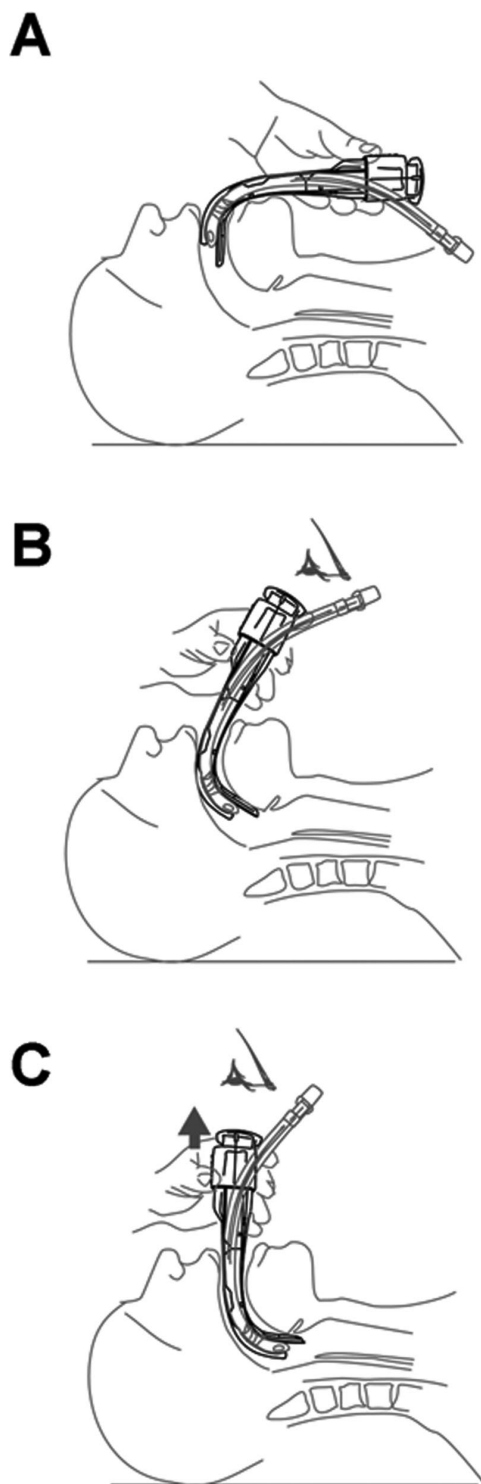
Thereafter, in all patients, the lungs were mechanically ventilated for the duration of the procedure, and anesthesia was maintained with sevoflurane (1.25–1.75%) in a mixture of nitrous and oxygen in a 2:1 ratio. No other medications were administered and no other procedures were performed during the 5-min data collection period after tracheal intubation. Further management was left to the discretion of the anesthesiologist providing care for the patient.

The primary endpoints were the duration of the tracheal intubation procedure and the IDS score.<sup>18</sup> The duration of the intubation attempt was defined as the time taken from insertion of the blade between the teeth until the ETT was placed through the vocal cords, as evidenced by visual confirmation by the anesthesiologist. However, in patients in whom the ETT was not directly visualized passing through the vocal cords, the intubation attempt was not considered complete until the ETT was connected to the anesthetic circuit and evidence was obtained of the presence of carbon dioxide in the exhaled breath. The IDS score, developed by Adnet *et al.*,<sup>18</sup> is a quantitative scale of multiple indices of intubation difficulty that can more objectively compare the complexity of tracheal intubations (appendix).

A secondary endpoint was the rate of successful placement of the ETT in the trachea. A failed intubation attempt was defined as an attempt in which the trachea was not intubated or an attempt that required more than 120 s to perform. Additional endpoints included the number of intubation attempts and the number of optimization maneuvers required (use of a bougie, BURP, second assistant) to aid tracheal intubation, and the Cormack and Lehane grade at laryngoscopy.<sup>19</sup>

#### Statistical Analysis

We based our sample size estimation on the IDS score. An IDS score of 0 represents ideal intubating conditions, and increasing scores represent progressively more dif-



**Fig. 2.** Technique of tracheal intubation with the Airtraq laryngoscope. The device is held in the left hand and passed into the mouth over the tongue, in the midline (A). When the device has been passed over the back of the tongue, the view from the viewfinder is used to position the tip in the vallecula (B). The view of the glottis can be optimized by lifting the epiglottis by elevating the blade into the vallecula (C). When the glottis is in the center of the view seen from the viewfinder, the endotracheal tube is then passed from its position in the channel through the vocal cords. The endotracheal tube is then moved laterally to remove it from the channel, the device is withdrawn, and the endotracheal tube is secured.

difficult intubating conditions. Based on initial pilot studies, we projected an IDS score of 1 or greater in 70% patients with the Macintosh laryngoscope. We considered that a clinically important reduction in the number of patients with an IDS score greater than 0 in these low-risk patients would be a 30% reduction, *i.e.*, an IDS score of 1 or greater in 40% of patients. Based on these figures, using  $\alpha = 0.05$  and  $\beta = 0.2$ , for an experimental design incorporating two equally sized groups, we estimated that 20 patients would be required per group. We therefore aimed to enroll 20 patients per group.

Data for duration of intubation attempts were analyzed using the *t* test. Data for the success of tracheal intubation attempts were analyzed using the Fisher exact test. Data for the IDS score, the number of intubation attempts, and the number of optimization maneuvers were analyzed using the Mann-Whitney rank sum test. The comparisons of hemodynamic data within groups were analyzed using one-way repeated-measures analysis of variance. For these analyses, the preintubation data were chosen as baseline data, rather than the preinduction values. Between-group comparisons were made using an unpaired *t* test. Continuous data are presented as mean  $\pm$  SD, ordinal data are presented as median (interquartile range), and categorical data are presented as number and frequency. The  $\alpha$  level for all analyses was set as  $P < 0.05$ .

## Results

A total of 40 patients were entered into the study. Twenty patients were randomly assigned to undergo tracheal intubation with the Macintosh laryngoscope, whereas 20 underwent tracheal intubation with the Airtraq laryngoscope. There were no significant differences in demographic or baseline airway parameters between the groups (table 1). There were no between-group differences with regard to anesthetic management, with similar mean doses of propofol and fentanyl, and end-

**Table 1.** Demographic Characteristics of Patients Enrolled to the Study

Parameter Assessed	Macintosh	Airtraq
Male:female ratio	9:11	8:12
Age, yr	45.7 $\pm$ 16.4	43.6 $\pm$ 19.4
Body mass index, kg/m <sup>2</sup>	26.4 $\pm$ 4.4	24.4 $\pm$ 3.1
ASA physical status, median (IQR)	2 (1–2)	2 (1–2)
Airway measurements, cm		
Thyromental distance	6.5 $\pm$ 0.6	6.4 $\pm$ 0.4
Interincisor distance	4.8 $\pm$ 0.7	4.6 $\pm$ 0.6
Mallampati classification		
1	13 (65)	12 (60)
2	7 (35)	8 (40)
> 2	0	0

Data are mean  $\pm$  SD or n (%).

ASA = American Society of Anesthesiologists; IQR = interquartile range.



tidal sevoflurane after tracheal intubation in both groups (table 2).

All patients were successfully intubated on the first attempt with the Airtraq laryngoscope, whereas three attempts were required in one patient with the Macintosh laryngoscope (table 3). The Airtraq significantly reduced median IDS score (table 3), and improved Cormack and Lehane glottic view obtained at laryngoscopy (fig. 4), compared with the Macintosh group. Fourteen patients in the Macintosh group had an IDS score of 1 or greater, compared with one in the Airtraq group. In the Macintosh group, four patients had an IDS score of 5 or greater, indicating moderate to severe intubation difficulty (fig. 3). The duration of intubation attempts were significantly shorter with the Airtraq (table 3). Fewer maneuvers were required in the Airtraq group to improve the glottic exposure, compared with the Macintosh group (table 3). There was no between-group difference in the incidence of complications, with two patients experiencing bruising to the lip with the Macintosh, compared with no injuries seen with the Airtraq, or in the lowest oxygen saturation during intubation attempts (table 3). There was no incidence of dental or other airway trauma with either laryngoscope.

Tracheal intubation with the Macintosh resulted in a significant increase in heart rate and mean arterial blood pressure, compared with preintubation values, in contrast to the Airtraq. There were significant between-group differences in heart rate and mean blood pressure at all time points after intubation (figs. 5 and 6).

## Discussion

Although the frequency of airway management aggravating preexisting cervical spine injury is unclear, it is likely to be relatively low.<sup>4</sup> However, cervical spine injury resulting in quadriplegia has been previously reported in association with airway management in a patient in whom cervical spine immobilization was not performed.<sup>1</sup> The evidence base supporting the use of MIAS is surprisingly limited. In anatomical studies, after complete C4–C5 ligamentous injury, MIAS did reduce segmental angular rotation and distraction, although it did increase subluxation, compared with nonimmobilization.<sup>3</sup> In a case series of 150 patients with traumatic

**Table 2. Anesthetic Regimen**

	Macintosh	Airtraq
Induction of anesthesia		
Fentanyl, $\mu\text{g/kg}$	$1.37 \pm 0.25$	$1.46 \pm 0.24$
Propofol, $\text{mg/kg}$	$2.67 \pm 0.58$	$2.37 \pm 0.58$
Atracurium, $\text{mg/kg}$	$0.53 \pm 0.10$	$0.55 \pm 0.10$
Maintenance of anesthesia		
Oxygen:nitrous oxide ratio	40:60	40:60
Sevoflurane (end-tidal), %*	$2.27 \pm 0.62$	$2.10 \pm 0.59$

\* Measured immediately after tracheal intubation.

**Table 3. Data for Intubation Attempts with Each Device**

Parameter Assessed	Macintosh	Airtraq
Overall success rate (%)	19 (95)	20 (100)
Intubation difficulty scale score	2 (0.3)	0 (0.0)†
Duration of intubation attempt, s	$20.3 \pm 12.2$	$13.2 \pm 5.4^*$
Lowest $\text{SpO}_2$ during intubation attempt, %	$98.7 \pm 1.4$	$99.4 \pm 0.7$
No. of intubation attempts (%)		
1	19 (95)	20 (100)
2	0	0
3	1 (5)	0
No. of optimization maneuvers (%)		
0	12 (60)	20 (100)*
1	5 (25)	0
$\geq 2$	3 (15)	0

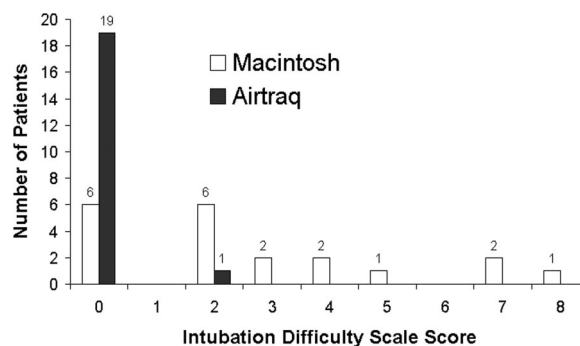
Data are mean  $\pm$  SD, median (interquartile range), or n (%).

\* Significantly ( $P < 0.05$ ) different compared with the Macintosh laryngoscope. † Significantly ( $P < 0.001$ ) different compared with the Macintosh laryngoscope.

$\text{SpO}_2$  = oxygen saturation measured by pulse oximetry.

cervical spine injuries with well-preserved neurologic function, oral tracheal intubation with MIAS, whether performed after induction of general anesthesia or with the patient awake, did not result in any neurologic complications.<sup>4</sup> It is therefore an accepted practice in many institutions to remove rigid collars and use MIAS for cervical immobilization during tracheal intubation in patients with suspected or proven cervical spine injury.

A key concern remains the fact that glottic views obtained during direct laryngoscopy with cervical spine immobilization are consistently poorer, compared with nonimmobilized controls.<sup>5,6</sup> MIAS prevents head extension and neck flexion, which are necessary for optimal alignment of the three airway axes and exposure of the vocal cords using direct laryngoscopic techniques. Avoidance of use of a pillow further limits optimization of intubating position. Alternative approaches to neck immobilization, such as the use of a rigid collar, tape, and sandbags, may result in an increased incidence of grade 3 and 4 laryngoscopic views (up to 64%) with conventional laryngoscopy owing to the combination of



**Fig. 3. Comparison of intubation difficulty scale score distributions with the Airtraq versus Macintosh laryngoscopes. Number of patients is shown above each bar.  $P < 0.001$  between groups, Mann–Whitney U test.**

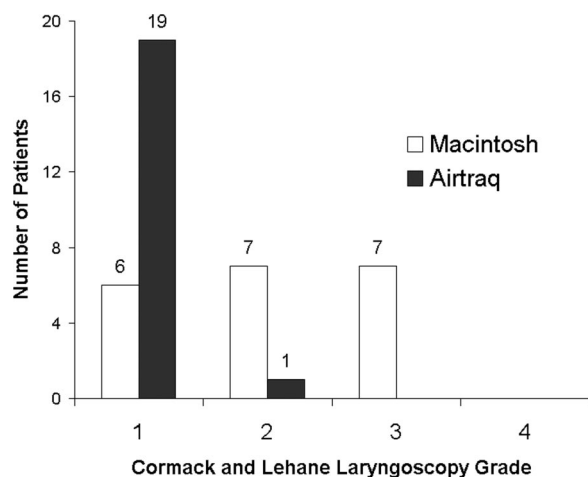


Fig. 4. Cormack grade view during the first intubation attempt with the Airtraq versus Macintosh laryngoscopes. Number of patients is shown above each bar.  $P < 0.001$  between groups, Mann-Whitney U test.

decreased interincisor distance and cervical spine immobility.<sup>7</sup>

The adequacy of the laryngeal view obtained is a major factor in determining the difficulty of intubation.<sup>6</sup> Consequently, maneuvers to stabilize the neck in patients at risk of cervical spinal injury may result in failure to secure the airway, which may result in substantial morbidity and even mortality in this patient group. These issues highlight the need to develop alternative approaches to securing the airway in patients at risk of cervical spine injury.

Our group has previously already assessed performance of the Airtraq in manikins when used by anesthesiologists,<sup>14</sup> relatively inexperienced medical personnel,<sup>15</sup> and novice users<sup>16</sup> and in patients at low risk for difficult intubation.<sup>17</sup> These studies demonstrated potential advantages, in both easy and simulated difficult la-

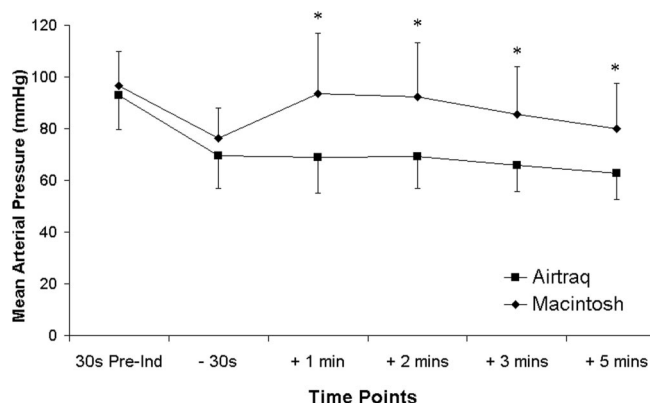


Fig. 5. Graph representing the changes in heart rate following tracheal intubation with each device. Data are mean  $\pm$  SD. \* Significantly different compared with the Airtraq laryngoscope. 30 s Pre-Ind = 30 s before induction of anesthesia; -30 s = 30 s before tracheal intubation; +1 min = 1 min after tracheal intubation; +2 min = 2 min after tracheal intubation; +3 min = 3 min after tracheal intubation; +5 min = 5 min after tracheal intubation.

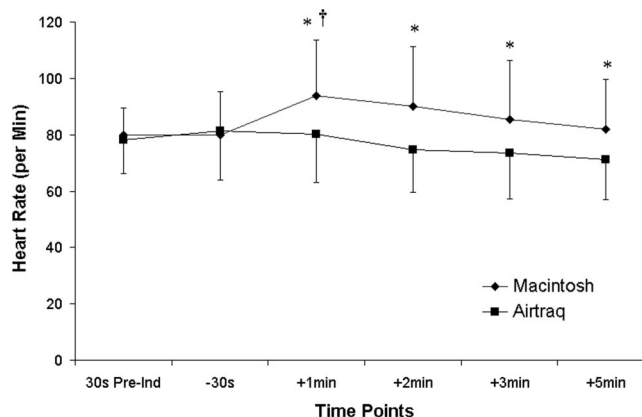


Fig. 6. Graph representing the changes in mean arterial blood pressure after tracheal intubation with each device. Data are mean  $\pm$  SD. \* Significantly different compared with the Airtraq laryngoscope. † Significant difference compared with preintubation value. 30 s Pre-Ind = 30 s before induction of anesthesia; -30 s = 30 s before tracheal intubation; +1 min = 1 min after tracheal intubation; +2 min = 2 min after tracheal intubation; +3 min = 3 min after tracheal intubation; +5 min = 5 min after tracheal intubation.

ryngoscopy scenarios. Specifically, we have demonstrated improved intubating conditions in a patient simulator with reduced cervical range of movement.<sup>14</sup> We therefore wished to compare the utility of the Airtraq with that of the Macintosh laryngoscope in patients after cervical spine immobilization, in this randomized, controlled clinical trial. Previous studies have used this model of simulated cervical spine to assess optimal intubation technique in similar patient populations.<sup>20,21</sup> All intubations in this study were performed by one of four experienced anesthesiologists in patients deemed on clinical assessment to be at low risk for difficult tracheal intubation. Each anesthesiologist had performed more than 500 intubations with the Macintosh laryngoscope and at least 50 intubations with the Airtraq in manikins, and 50 intubations with the Airtraq in patients, before this study.

Our study demonstrated that, in comparison with the Macintosh laryngoscope, the Airtraq provided superior intubating conditions in patients undergoing cervical immobilization with MIAS. The Airtraq resulted in reduced duration of intubation attempts and reduced IDS scores. The Cormack and Lehane grading system, although originally designed to compare glottic views at direct laryngoscopy,<sup>19</sup> provided a useful comparison of the direct and indirect laryngoscopic views achieved in this study. Nineteen patients intubated with the Airtraq had a grade I Cormack and Lehane glottic view, compared with six patients in the Macintosh group. Fewer patients required additional maneuvers to improve glottic exposure with the Airtraq device. However, the limitations of this latter measurement are acknowledged.

The Airtraq resulted in less stimulation of heart rate and blood pressure after tracheal intubation in comparison with the Macintosh laryngoscope. This finding

probably reflects the fact that the Airtraq provides a view of the glottis without a need to align the oral, pharyngeal, and tracheal axes, and therefore requires less force to be applied during laryngoscopy. The hemodynamic findings for direct laryngoscopy in our study were similar to those described previously.<sup>17,22–24</sup> The potential of the Airtraq to produce less stimulation of heart rate may be particularly advantageous in clinical situations such as coronary artery disease or arrhythmias.

An important potential advantage of the Airtraq is that it is a single-use device. This removes concerns regarding the potential for multiuse intubation devices to facilitate transmission of prions, which are thought to be responsible for causing variant Creutzfeldt–Jakob disease.<sup>25,26</sup> These concerns arise from the difficulties in ensuring that all proteinaceous material has been removed from reusable laryngoscope blades during cleaning and sterilization.<sup>27,28</sup> In recognition of these concerns, the guidelines of the Association of Anesthetists of Great Britain and Ireland state that “single use intubation aids” should be used where possible.<sup>29</sup> The relatively low cost of this device in comparison with reusable indirect laryngoscopes allows for this device to be provided at multiple locations within the hospital in which a difficult intubation may be encountered, such as in the emergency room and the obstetric, radiologic, and ambulatory surgical suites. Our study demonstrates that the Airtraq is at least as effective as the reusable Macintosh bladed laryngoscope, attesting to its safety in this regard. Potential disadvantages of disposable device such as the Airtraq do exist, including increased cost, the potential for breakage, and issues surrounding the quality of image obtained. However, in our experience with the Airtraq, we have not encountered problems with breakage or with image quality to date.

A number of important limitations exist regarding this study. In particular, we acknowledge that the potential for bias exists, because it is impossible to blind the anesthesiologist to the device being used. Furthermore, certain measurements used in this study, such as laryngoscopic grading, are by their nature subjective. However, there was good agreement between subjective indices of difficulty of intubation and more objective measures, such as the IDS score.<sup>18</sup> In addition, the possibility remains that factors other than the difficulty of laryngoscopy may have contributed to our hemodynamic findings. However, these findings are not explained by between-group differences in the anesthetic regimen, because there were no differences in the anesthetic agents used in each group. Furthermore, our hemodynamic data for intubation with the Macintosh laryngoscope are consistent with previously reported data,<sup>17,22–24</sup> whereas the time required for tracheal intu-

bation with the Macintosh laryngoscope was shorter than previously described. This study was conducted by experienced users of each device. The results may differ when the procedures are performed by less experienced users. Finally, the Airtraq was compared with the Macintosh laryngoscope in this study, because this remains the accepted standard. Similar results to that seen with the Airtraq have been demonstrated with other indirect laryngoscopes, such as the Bullard (Circon Corporation, Stamford, CT),<sup>30</sup> GlideScope (Saturn Biomedical Systems, Inc., Burnaby, BC, Canada),<sup>31</sup> and WuScope (Pentax Precision Instruments, Orangeburg, NY).<sup>6</sup> Further comparative studies are needed to determine the relative efficacies of these devices.

In conclusion, the Airtraq laryngoscope offers a new approach to tracheal intubation of patients who require cervical spine immobilization. The Airtraq reduced the difficulty of tracheal intubation and the degree of hemodynamic stimulation compared with the Macintosh laryngoscope in these patients. These findings demonstrate the efficacy of the Airtraq in a clinically relevant context and add to the evolving body of knowledge regarding this potentially useful device. Further studies in the clinical context, particularly in predicted difficult intubation scenarios, are necessary to confirm and extend these positive findings.

## Appendix: Intubation Difficulty Scale Score

The IDS score<sup>18</sup> is the sum of the following seven variables:

- N1: Number of intubation attempts greater than 1
- N2: Number of operators greater than 1
- N3: Number of alternative intubation techniques used
- N4: Glottic exposure (Cormack and Lehane grade minus 1)
- N5: Lifting force required during laryngoscopy (0 = normal; 1 = increased)
- N6: Necessity for external laryngeal pressure (0 = not applied; 1 = applied)
- N7: Position of the vocal cords at intubation (0 = abduction/not visualized; 1 = adduction)

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<sup>18</sup> Intubation difficulty scale score from Adnet *et al.*<sup>18</sup>; reproduced with permission.

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