

Airtraq vs standard laryngoscopy by student paramedics and experienced prehospital laryngoscopists managing a model of difficult intubation*

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Summary

Two consecutive, randomised, cross-over trials compared intubation success rates in third-year paramedic students and experienced prehospital practitioners using the Airtraq or a Macintosh laryngoscope with flexible stylet in a manikin model of a Cormack and Lehane grade III/IV laryngoscopic view. First-time intubation rates for the Macintosh and Airtraq for students were 0/23 (0%) vs 10/23 (44%) (44% difference, 95% CI 26–63%, $p < 0.001$) and for experienced laryngoscopists were 14/56 (25%) vs 47/56 (84%) (59% difference, 95% CI 42–72%, $p < 0.0001$), respectively. First-time oesophageal intubation rates for students were 15/23 (65%) vs 3/23 (13%) (– 52% difference, 95% CI – 25 to – 72%, $p < 0.001$) and for experienced practitioners 9/56 (16%) vs 0/56 (0%) (– 16% difference, 95% CI – 9 to – 28%, $p = 0.0014$). Student paramedics and experienced prehospital laryngoscopists managing a manikin model of a grade III/IV view had increased first-time intubation rates and had lower rates of oesophageal intubation with the Airtraq compared with a standard laryngoscope.

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One of the main criticisms of paramedics' tracheal intubation skills concerns the frequency of unrecognised misplaced tracheal tubes. An observational study of 108 paramedic tracheal intubations identified that 25% of patients had misplaced tracheal tubes, of which 67% were noted to be in the oesophagus [1]. A similar study of 167 paramedic tracheal intubations reported that 12% were misplaced with >75% in the oesophagus [2], and a prospective observational study of 208 paramedic tracheal intubations reported unrecognised misplaced tracheal tubes in 5.8% of patients (95% CI = 2.6–8.9%) [3].

A UK study of paramedic tracheal intubation in 52 patients reported a cumulative success rate of only 71.2%

after two attempts [4]. This research also found that although 87.5% of patients with a Cormack and Lehane grade I view and 56.3% of patients with a grade II view were successfully intubated, no patient with a grade III or IV view had a tracheal tube correctly placed. These findings led the authors to suggest that intubation be withdrawn from the UK paramedic skill base. A recent literature review examining out-of-hospital intubation has also identified concerns about 'adverse events and errors, interaction with other important resuscitation interventions, and challenges in providing and maintaining procedural skill' [5]. The review highlighted the need for new strategies to improve airway management in this setting.



Figure 1 The Airtraq device.

The Airtraq[®] laryngoscope (Prodol Meditec S.A., Vizcaya, Spain) is a single-use disposable intubation device that allows the laryngoscopist to view the glottis without having to achieve alignment of the oral, pharyngeal and laryngeal axes (Fig. 1). The blade of the Airtraq is shaped to match the pharyngeal contour of the oral airway and consists of two parallel channels, one housing the optical apparatus (simple plastic prisms and lenses) for indirect visualisation of the laryngeal structures, and the other functioning as a guide for the tracheal tube.

There has been little research published on the Airtraq laryngoscope. A small manikin study of 25 anaesthetists comparing skill acquisition with the Airtraq vs a standard Macintosh laryngoscope reported a shorter time to intubation with the Airtraq (9.5 vs 14.2 s) [6]. A further study of 40 medical students with no prior airway management experience reported that in comparison with a Macintosh laryngoscope the Airtraq was associated with higher success rates, reduced duration of intubation attempts, and reduced potential for dental trauma [7].

Tracheal intubation provides definitive airway management. However, the skill of using a laryngoscope to facilitate intubation is difficult to acquire and retain, particularly given the limited training opportunities available to most paramedics. If the Airtraq improves paramedic tracheal intubation success rates it has the potential to improve the outcome of patients whom it might otherwise be impossible to intubate. Early intubation in prehospital cardiac arrest has been shown to improve the probability of survival [8]. Despite this, rapid sequence induction anaesthesia is increasingly being added to the interventions permitted for use by paramedics.

The first of two studies reported in this paper aimed to determine whether use of the Airtraq by pre-employment

third-year student paramedics resulted in improved intubation success rates compared with standard laryngoscopy in a manikin model of a Cormack and Lehane grade III/IV laryngoscopic view. The second study compared the intubation success rates of experienced prehospital laryngoscopists when managing the same model of a difficult intubation using either an Airtraq or a Macintosh laryngoscope.

Methods

Approval for both studies was obtained from the Ethics in Human Research Committee, Charles Sturt University. Potential volunteers were given an information sheet and a briefing by a researcher, with an opportunity to ask questions. Written informed consent was obtained from all subjects agreeing to participate in both studies. Data were anonymised and information on the performance of individual participants was not made available to anyone outside of the study team.

The first randomised cross-over trial sought volunteers from a convenience sample of students undertaking their third year of studies for a Bachelor of Clinical Practice (Paramedic) degree program during the third week of October 2006. All volunteers had previously participated in a minimum of 8 h of manikin-based intubation training using standard laryngoscopy techniques as part of their program of education. All were taught the theory of how to use the Airtraq in a 20-min didactic session, supported by a 3.5-min video demonstration, 12 Powerpoint slides, and an animation. They were then isolated from their peers for a 10-min supervised practice period using an unmodified airway manikin. To put them at their ease they were first invited to intubate the manikin twice using a standard laryngoscope, and were then coached in the correct technique for inserting the Airtraq. When the student had successfully used the Airtraq to place a tracheal tube once they were permitted to decide for themselves how to divide the remainder of the 10-min period between practice with the Airtraq and Macintosh laryngoscopes.

For the purposes of the study, the students were asked to intubate a manikin model of a Cormack and Lehane grade III/IV laryngoscopic view (epiglottis visible but no other glottic structures seen or no structures seen, depending on individual practitioners' skill). The view was restricted by strapping a Laerdal Advanced Life Support Manikin (MegaCode Kelly, Laerdal Pty. Ltd, Victoria, Australia) to a long spine board, immobilising the head, applying a cervical collar, and inflating the tongue [9]. Students' intubation success rates with an 8.0-mm cuffed tracheal tube using a standard laryngoscope (Macintosh size three) and a malleable stylet were

compared with those achieved using an Airtraq. They were asked to make three successive intubation attempts, limited to 60 s each, with both devices. The sequence in which individual paramedics used each device was randomised using a statistical software package (SPSS version 10.0.5, SPSS Inc., Chicago, IL, USA). A successful intubation was defined as placement of the tube in the trachea permitting the ventilation of the manikin 'lungs' via the tube within 30 s of the last ventilation with the bag-valve-mask. Immediately after three intubation attempts with a device, students were asked to rate its difficulty of use by marking a 10-cm line, with 0 cm representing 'very easy' and 10 cm representing 'very hard'. Time to intubation and correct positioning of the tracheal tube were assessed independently by two researchers. Data were documented immediately after each intubation and later transferred directly into a statistical software package (SPSS version 10.0.5) and checked for integrity by two researchers. The primary outcome measure was the between-device difference in the proportion of students successfully intubating the trachea at the first attempt within a breath-to-breath interval of less than 30 s. The secondary outcome measures were the between-device difference in the total number of 'patients' successfully intubated (cumulative success rate in maximum of three attempts), the between-device difference in oesophageal intubation rates and the between-device difference in student-rated difficulty of use score, using a visual analogue scale.

P values and 95% confidence intervals for differences in proportions were calculated using STATS DIRECT software (version 2.4.4, StatsDirect Ltd, Altrincham, UK). Data were entered into SPSS, and Wilcoxon's signed ranks test was used to compare subjects self-assessed ease of use scores. A p value < 0.05 was considered to be significant. No previous relevant research was available to permit a valid sample size calculation to be performed. Consequently, we aimed to recruit a non-random sample based purely on students' availability and willingness to participate at the time of the study.

The second randomised cross-over study sought volunteers from prehospital practitioners trained and authorised to practise intubation who were attending the Australian College of Ambulance Professionals Conference in Adelaide, Australia, in November 2006. A stand was set up in the trade hall (manned solely by researchers) and potential subjects were recruited during breaks in the conference. While queuing to participate, possible recruits were given a handout to read that included a written and diagrammatic description of the technique for using the Airtraq, in addition to a study participant information sheet. A researcher subsequently demonstrated and explained the use of the Airtraq on a one-

to-one basis, and each volunteer was permitted one practice attempt with the Airtraq only. The experienced laryngoscopists in this trial were limited to only one 30-s intubation attempt with each device. Once again, a Macintosh laryngoscope plus malleable stylet was used as the comparator, although this time a size four blade was fitted. With the exception of the differences described here, the design of this second study (including the model of a difficult intubation) was identical to that of the first.

Based on the increase of 44% in first-time intubation success rates with the Airtraq compared to a Macintosh laryngoscope found in the first (student) study, we calculated that a minimum of 23 subjects would be required to detect a similar difference with a 95% confidence interval (CI) of 26–63%. However, as we felt that experienced laryngoscopists might have higher success rates with a traditional laryngoscope, we aimed to recruit a minimum of 50 subjects in this second study.

Results

Twenty-three students volunteered to take part in the first study. The mean age of study participants was 24 years (SD 3.94). Eleven subjects were randomly allocated to use the Macintosh laryngoscope first. The only protocol violation was the loss of data from one intubation attempt with a Macintosh laryngoscope. This had to be abandoned due to the tongue of the manikin bursting as a result of the vigour of the intubation attempt. After three intubation attempts students successfully intubated 18/23 (78%) of simulated patients using the Airtraq compared with 7/23 (30%) with the Macintosh (Table 1). There was evidence of learning through practice with the Airtraq, as success rates were higher with successive intubation attempts: this effect was less marked with the Macintosh. There was a greater proportion of oesophageal intubations when the Macintosh laryngoscope was used by students, with a significantly lower error rate for all attempts with the Airtraq (Table 2). The median student-rated difficulty of use visual analogue score for the Airtraq was 21 (IQR 15–50 (range 0–100)), compared with 88 for the Macintosh (IQR 78–97 (range 37–100)), $p < 0.001$ (higher values = more difficult).

Fifty-six experienced laryngoscopists volunteered to take part in the second study. The median age of study participants was 39 years (IQR 35–45 years (range 27–60 years)). Two of the volunteers were doctors, the rest were advanced life support-trained ambulance personnel. Twenty-nine subjects were randomly allocated to use the Macintosh laryngoscope first. The key outcome measures for each laryngoscope are described in Table 3. The median practitioner-rated difficulty of use visual analogue

Table 1 Cumulative intubation success rates (student paramedics) (% and 95% CI or 95% CI and p value).

	Macintosh	Airtraq	Difference in proportions
One attempt	0/23 (0%, 0–17%)	10/23 (44%, 26–63%)	44% (26–63%, $p < 0.001$)
Two attempts	5/23 (22%, 9–42%)	15/23 (65%, 45–81%)	43% (15–65%, $p < 0.004$)
Three attempts	7/23 (30%, 15–51%)	18/23 (78%, 58–91%)	48% (19–69%, $p < 0.002$)
Intubation never achieved	16/23 (70%, 49–85%)	5/23 (22%, 9–42%)	– 48% (– 69 to – 19%, $p < 0.002$)

Table 2 Oesophageal intubation rates per attempt (student paramedics) (% and 95% CI or 95% CI and p value).

	Macintosh	Airtraq	Difference in proportions
Attempt one	15/23 (65%, 45–81%)	3/23 (13%, 4–33%)	– 52% (– 25 to – 72%, $p < 0.001$)
Attempt two	12/23 (52%, 33–71%)	2/23 (9%, 1–28%)	– 44% (– 14 to – 65%, $p = 0.002$)
Attempt three	13/23 (57%, 37–74%)	1/23 (4%, 0–23%)	– 52% (– 28 to – 71%, $p < 0.001$)

Table 3 Between-device comparisons (experienced laryngoscopists). (% and 95% CI or 95% CI and p value).

	Macintosh	Airtraq	Difference in proportions
Tracheal tube correctly sited within 30 s	14/56 (25%, 15–38%)	47/56 (84%, 72–92%)	+ 59% (+ 42 to + 72%, $p < 0.0001$)
Oesophageal intubation rate	10/56 (18%, 10–30%)	0/56 (0%, 0–8%)	– 18% (– 30 to – 10%, $p = 0.0006$)
Failure rate (excluding oesophageal intubations)	32/56 (57%, 44–69%)	9/56 (16%, 9–28%)	– 41% (– 56 to – 24%, $p < 0.0001$)

score for the Airtraq was 20 (IQR 5–28 (range 1–75)) compared with 86 for the Macintosh (IQR 71–93 (range 12–100)), $p < 0.001$.

We made a number of non-empirical observations that were similar for both studies. It was noted that significant dental damage would potentially have been inflicted on a 'real' patient during all Macintosh intubation attempts and successes, due to the study participants vigorously levering back on the upper dentition of the manikins in an attempt to improve their view of the glottis. Second, most oesophageal intubations were reported by students as 'suspected' before formal confirmation by researchers. Finally, when using the Airtraq, participants consistently reported an excellent view of the glottis regardless of whether or not the intubation attempt was successful.

Discussion

Our studies suggest that in the hands of both inexperienced and experienced prehospital laryngoscopists, the Airtraq device improves first-time tracheal intubation success rates in a model of difficult intubation when compared with use of a Macintosh laryngoscope.

Previous research in patients (presumably with a range of difficulty of laryngoscopic view) has reported that first-time intubation success rates using standard techniques are less than is desirable. A prospective, multicentre study involving 42 different ambulance agencies over 18 months reported an overall out-of-hospital tracheal intubation success rate of 91.8% (95% CI 90.2– 93.3%) in a cohort of 1272 cardiac arrests, identifying that success rates progressed from 69.9% to 84.9% to 89.9% for the first, second and third attempts, respectively [10]. A cumulative success rate after two attempts by paramedics of 71% has been reported [4]. Although these rates are greater than those in our study of students for both the Macintosh (first time success rate 0%, second time 22%, cumulative rate after two attempts 22%) and the Airtraq (first time success rate 44%, second time 57%, cumulative rate after two attempts 65%), it should be remembered that our trial focused on a model of difficult intubation. Indeed, it has been reported elsewhere that paramedics' intubation success rates in patients with such poor views has been as low as 0% [4]. The success rate of experienced laryngoscopists using the Airtraq in our second study of a grade III/IV view (84%) compares favourably with this

finding. Caution must be exercised, however, when comparing data from human and manikin studies and it is unclear how representative models are of live patients.

Rates of unidentified oesophageal intubation by paramedics in patients have been reported to range from 9 to 17% [1, 2]. In our first study, students' rates of oesophageal intubation were 65% at first intubation attempt when the Macintosh was used compared with 13% for the Airtraq. In the second study, when used by experienced laryngoscopists, the Airtraq seemed to confer an even greater benefit, resulting in no oesophageal intubations at all, compared with 16% when the same group used a size four Macintosh blade and stylet. Again, it is noteworthy that paramedics performing in patient studies would have been presented with a range of grades of airway view, whereas our subjects were only asked to intubate a model of a challenging grade III or IV view. However, the caution needed when comparing results from manikin-based research with patient studies still applies, and a well-designed randomised controlled trial in prehospital patients is essential before concluding that the Airtraq may offer a means to improve paramedics' intubation success rates whilst reducing the incidence of misplaced tracheal tubes.

There are a number of limitations to our studies. For the first study we relied on volunteers and it is likely therefore that there may have been sampling bias as a result of the participation of only enthusiastic students. Participants in the relevant paramedic degree program have the opportunity to undertake additional practice in clinical skills if they wish. Our study population may therefore have had more practice time with a Macintosh laryngoscope than their non-participating peers. If this is the case, standard intubation success rates may be lower in a more representative (less motivated) student population, although it is unclear whether this would also have been true for use of the Airtraq. In the second study, recruiting volunteers from attendees at a clinically focused conference also risks sampling bias, as this population is, arguably, more likely to consist of practitioners with a greater commitment to their on-going education. They may, therefore, be more skilled in tracheal intubation than members of their peer group who did not attend. However, our cross-over design will have eliminated much of this bias, as we compared differences in performance within the same individuals. Nevertheless, it is possible that other members of the prehospital professions may have found greater or lesser benefit from use of the Airtraq.

We have reported that many of our participants levered back with the Macintosh laryngoscope on the upper teeth and jaw of the manikin. This revealed an important flaw in our model of a difficult airway, as

these structures were considerably more flexible in the manikin than would be the case in 'real' patients. Our model was not therefore capable of registering the damage that levering back on the teeth might cause in clinical practice. As with all trials involving models, the level of fidelity is uncertain with respect to their ability to predict outcome in patients.

In summary, we believe that further research is required to determine whether the findings of these studies would be duplicated in patients; however, based on this and other research with the Airtraq, we believe that randomised controlled patient trials in the prehospital setting are justifiable. In the meantime, the studies reported in this paper have demonstrated that, in a manikin model of difficult intubation, both student paramedics and experienced prehospital laryngoscopists rate the Airtraq as significantly easier to use than a Macintosh laryngoscope with a malleable stylet after minimal additional training. Both groups achieved significantly higher first-time intubation success rates and significantly fewer failed and oesophageal intubations with the Airtraq device.

Potential conflict of interest

The Airtraq laryngoscopes used during the study were provided without charge by Prodol, the manufacturers of the device. None of the study sponsors had any role in the study design, collection, analysis or interpretation of data; or in the writing of the manuscript and in the decision to submit it for publication.

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