

RESPIRATION AND THE AIRWAY

Tracheal intubation of morbidly obese patients: a randomized trial comparing performance of Macintosh and Airtraq™ laryngoscopes

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Background. The Airtraq™ laryngoscope is designed to allow visualization of the glottis without alignment of the oral, pharyngeal, and laryngeal axes. We hypothesized that this new airway device would facilitate tracheal intubation of morbidly obese patients. We compared tracheal intubation performance of standard Macintosh laryngoscope with the Airtraq™ laryngoscope in morbidly obese patients.

Methods. One hundred and six consecutive ASA I–III morbidly obese patients undergoing surgery were randomized to intubation with the Macintosh laryngoscope or the Airtraq™ laryngoscope. Induction of anaesthesia was standardized. If tracheal intubation failed within 120 s with the Macintosh or Airtraq™ laryngoscopes were switched. Success rate, Sp_{O₂}, duration of tracheal intubation, and quality of airway management were evaluated and compared between the groups.

Results. Preoperative characteristics of the patients were similar in both groups. In the Airtraq™ group, tracheal intubation was successfully carried out in all patients within 120 s. In the Macintosh laryngoscope group, six patients required intubation with the Airtraq™ laryngoscope. The mean (SD) time taken for tracheal intubation was 24 (16) and 56 (23) s, respectively, with the Airtraq™ and Macintosh laryngoscopes, ($P < 0.001$). Sp_{O₂} was better maintained in the Airtraq™ group than in the Macintosh laryngoscope group with one and nine patients, respectively, demonstrating drops of Sp_{O₂} to 92% or less ($P < 0.05$).

Conclusions. In this study, the Airtraq™ laryngoscope shortened the duration of tracheal intubation and prevented reductions in arterial oxygen saturation in morbidly obese patients.

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The Airtraq™ (Prodol Meditec S.A., Vizcaya, Spain) is a single-use laryngoscope designed to facilitate tracheal intubation of normal and difficult airway patients (Fig. 1). Reports have been published on the use of the Airtraq™ in normal airway patients¹ and in simulated difficult airway scenarios in manikins.² The Airtraq™ was superior to the Macintosh laryngoscope in manikins, when a difficult airway due to increased tongue volume was simulated.² We have successfully used the

Airtraq™ for rapid tracheal intubation in morbidly obese pregnant women undergoing emergency Caesarean section.³ Because morbid obesity is thought to be associated with an enlargement of the tongue,^{4 5} we hypothesized that the Airtraq™ would shorten the time required to secure the airway of morbidly obese patients. We conducted a comparative study of the performance of the Macintosh and Airtraq™ laryngoscopes in morbidly obese patients.

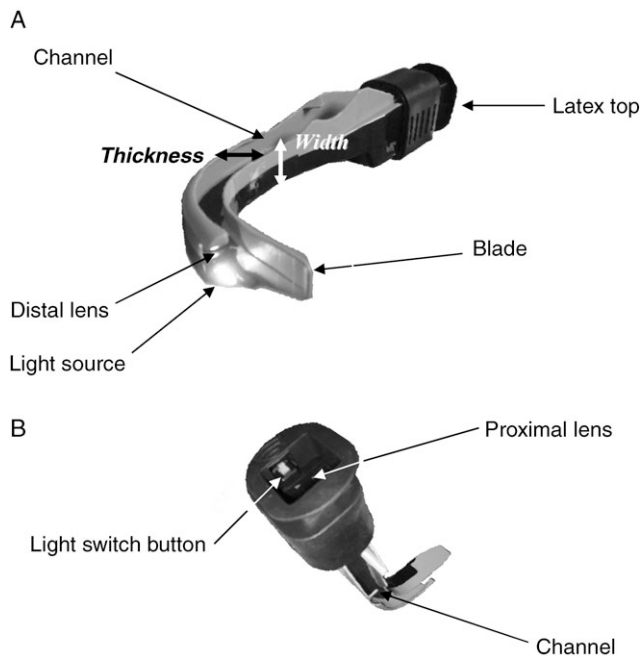


Fig 1 Horizontal (A) and vertical (B) views of the Airtraq™ laryngoscope. The square shaped proximal end of the laryngoscope contains the proximal lens, the batteries, and the video port. The distal part consists of the blade, the light source, and another lens, smaller than the proximal one. The light source heats the distal lens to prevent fogging. On the right side of the Airtraq™ body, there is a side channel which guides the endotracheal tube and from which it can be withdrawn sideways. The proximal lens (B) and the switch for the light are covered by a latex top (A, B). This latex top can be removed to fit a camera onto the proximal part of the Airtraq™.

Methods

Institutional ethics committee approval was obtained for this study and written informed consent was obtained from all patients. One hundred and six ASA I–III morbidly obese ($BMI > 35 \text{ kg m}^{-2}$) consecutive adult patients were enrolled in this prospective study. The patients underwent general, gynaecological, and bariatric surgery. Randomization to intubation with the Airtraq™ or Macintosh laryngoscope was performed using sealed envelopes opened by the anaesthesiologist in the operating room. All anaesthesiologists performing tracheal intubations were skilled in the use of the Airtraq™ and Macintosh laryngoscopes and frequently anaesthetize for obesity surgery. Patients with the history of hiatus hernia, symptomatic gastric reflux, gastric banding, allergy to succinylcholine, and those with mouth opening of less than 30 mm (interincisor distance) were not included in the study. At the end of each intubation, the anaesthesiologists were asked to rate facemask ventilation and overall airway management difficulty (VAS_{DIF}) on a simple visual analogue scale presented on a small ruler (0, very easy or no difficulty; 100, major difficulty or impossible). The operator was asked to mark the scale and the position of the mark was measured. The visual analogue scale of the overall airway management difficulty included the

Table 1 The intubation difficulty score

Variables	Score
Number (<i>n</i>) of attempts at intubation	<i>n</i> –1
Number (<i>n</i>) of operators attempting intubation	<i>n</i> –1
Number (<i>n</i>) of alternative intubation techniques used	<i>n</i>
Cormack and Lehane grade of laryngoscopy 1/2/3/4	0/1/2/3
Intense lifting pressure required	1
External pressure applied on the larynx	1
Mobile vocal cords	1
Intubation difficulty score = sum of the score of the seven variables	Intubation quality
Intubation difficulty score = 0	Easy
Intubation difficulty score = 1–5	Moderately difficult
Intubation difficulty score > 5	Very difficult to impossible

difficulty of the tracheal intubation. The latter was also assessed by calculation of the intubation difficulty score;⁶ the details of which are given in Table 1.

Anaesthetic technique

Patients were premedicated with oral hydroxyzine 100 mg. After arrival in the operating theatre, standard monitoring was installed. Patients were preoxygenated for 4 min using a facemask and oxygen 100%. When the expired oxygen concentration was above 90%, anaesthesia was induced with sufentanil $0.2 \mu\text{g kg}^{-1}$, propofol 2 mg kg^{-1} , and succinylcholine 1 mg kg^{-1} . The propofol dose was adjusted to lean body weight = $24 \cdot [\text{height}]^2$. Thirty seconds after drug administration, the patient was manually ventilated by facemask with oxygen 100% for 60 s before tracheal intubation. If the depth of anaesthesia as measured by the bispectral index increased to above 50 during airway management, further 50 mg boluses of propofol were given to bring the index below 50. Tracheal intubation was confirmed by the detection of expired carbon dioxide by capnography. At this stage, atracurium 0.5 mg kg^{-1} was administered and anaesthesia was maintained with sevoflurane (1.2–2%) in an oxygen/air mixture and sufentanil $0.1 \mu\text{g kg}^{-1}$ boluses.

Airway management procedures

For the Macintosh group, metallic reusable blades (sizes 3 and 4) were used for direct laryngoscopy. If the Cormack and Lehane grade was three or more, the use of a gum elastic bougie (VYGON, Écouen, France) was recommended to assist tracheal intubation.

For the Airtraq™ laryngoscope group, tracheal intubation was attempted using the inventor's technique (standard technique) for blade insertion into the oral cavity (Fig. 2). Once the view of the glottis was optimized, the tracheal tube was passed through the vocal cords and the cuff inflated. The tube was then held in place while the Airtraq™ laryngoscope was removed (Fig. 3).

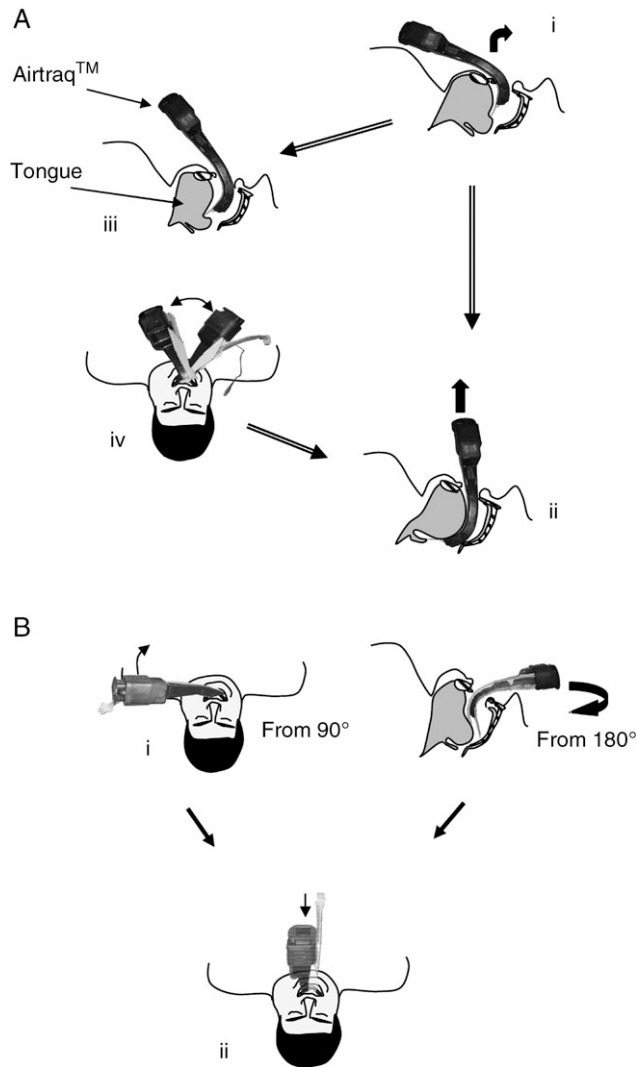


Fig 2 Intubating with the Airtraq™ laryngoscope. The head is placed in the neutral position. The standard technique (A) consists of sliding the tip of the Airtraq™ laryngoscope into the mouth along the tongue. The blade of the laryngoscope is kept in contact with the tongue (A-i) until the epiglottis comes into view (A-ii). If passage of the laryngoscope into the oropharynx is difficult (A-iii), crawling movements are used to move the blade over the tongue towards the epiglottis (A-iv). Once the tip of the laryngoscope is positioned in the vallecula, the laryngoscope is lifted straight up to expose the glottis (upper arrow, A-ii). For rotational insertion (B), the Airtraq™ laryngoscope is inserted into the mouth from 90° to 180° (B-i) to the usual direction and then rotated into the usual position (B-ii).

The technique selected by randomization was considered to have failed if tracheal intubation was not achieved within 120 s. We would then switch the type of laryngoscope—Macintosh to Airtraq™ or vice versa. If the Sp_{O_2} dropped below 92% during the 120 s of the tracheal intubation attempt, facemask ventilation was performed and the laryngoscope was switched. It was planned that in cases of difficult oxygenation in which the Sp_{O_2} fell below 92% and failed tracheal intubation with the two laryngoscopes, the LMA CTrach™ (SEBAC, Pantin, France)

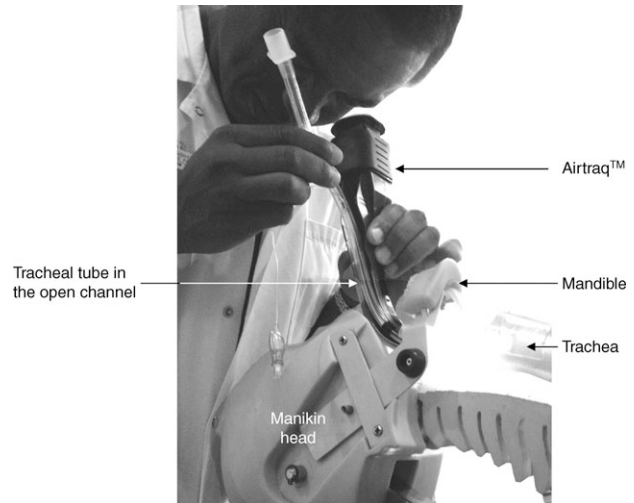


Fig 3 Photograph of an operator intubating a manikin with the Airtraq™. The operator slides the endotracheal tube along the channel along the Airtraq™. The tube is then removed from the Airtraq from the side opening channel.

would be used to ventilate and achieve tracheal intubation under visual control.

Airway management data

For both laryngoscopes, the duration of tracheal intubation and failure rate at 120 s were recorded. The person recording the data was an independent, unblinded, observer. Tracheal intubation duration was defined as the time elapsing between the insertion of the laryngoscope into the oral cavity and the visualization (or the sensation in the case of blind tracheal intubation) of the tube crossing the glottis. Episodes of hypoxaemia defined by drops of Sp_{O_2} to 92% or less and respiratory events including bronchospasm, regurgitation, and aspiration were noted. We used the intubation difficulty score to compare tracheal intubation difficulty between the two groups (Table 1).⁶ Easy, moderately difficult, and difficult tracheal intubation were defined by the intubation difficulty scores of 0, 1–5, and greater than 5, respectively. Post-tracheal intubation sore throat intensity was measured at discharge from the recovery room by a nurse using a visual analogue scale (VAS_{ST}) (0, no pain; 100, worst imaginable pain).

Statistics

In a large cohort of morbidly obese patients undergoing elective bariatric surgery, we recorded a 16% frequency of patients requiring more than 2 min to perform tracheal intubation using the Macintosh laryngoscope.⁷ We hypothesized that the Airtraq™ would allow tracheal intubation of all morbidly obese patients within 2 min. We calculated that 106 patients randomized into two groups were required to confirm this hypothesis with $\beta=0.8$ and $\alpha=0.05$. Fisher's exact test and the Mann–Whitney *U*-test were

applied for categorical and continuous data, respectively. Visual analogue scale scores are reported as median (range). Other continuous data are reported as means (SD) and *P*-values of <0.05 were considered statistically significant.

Results

No serious complications related to anaesthesia and airway management occurred. Both groups were comparable with regard to patient and preoperative airway characteristics (Table 2). No patients were excluded for poor mouth opening. Comparative airway management performance data are presented in Table 3. The mean duration of tracheal intubation mean (SD) was significantly shorter with the Airtraq™ laryngoscope than with the Macintosh laryngoscope, 24 (16) and 56 (23) s, respectively. (*P*<0.001) The median (range) VAS score for overall airway management difficulty was greater with Macintosh laryngoscope

than with Airtraq™ laryngoscope, 24 (10–65) and 12 (1–55), respectively (*P*<0.001). Tracheal intubation was successfully carried out within 120 s in all patients in the Airtraq™ laryngoscope group. Six patients in the Macintosh laryngoscope group required more than 2 min to complete tracheal intubation. These six patients were subsequently intubated with the Airtraq™ laryngoscope within a mean of 27(8) s. One patient had a fall in SpO₂ to below 92% in the Airtraq™ laryngoscope group when compared with 9 in the Macintosh laryngoscope group (*P*<0.05). The median (range) intubation difficulty score differed significantly between the Macintosh and the Airtraq™ laryngoscopes groups, 5 (2–10) and 0 (0–2), respectively (*P*<0.001). Details of intubation difficulty score for the two groups are presented in Table 4. Easy, moderately difficult, and difficult tracheal intubation as defined by the intubation difficulty score (0, 1–5, and >5) were encountered in 22, 20, and 11 patients of the Macintosh laryngoscope group, respectively. In contrast, tracheal intubation was easy in 49 patients and moderately difficult in only four patients in the Airtraq™ group.

The Airtraq™ laryngoscope was difficult to place in the pharynx of 11 patients and rotational manoeuvres for insertion illustrated in Figure 2B were used in four patients. Tracheal intubation was considered traumatic with blood spots on the laryngoscopes after tracheal intubation with the Macintosh and Airtraq™ laryngoscopes in seven and 10 patients, respectively. The increase in mean arterial pressure, heart rate (Table 5), and bispectral index (Table 3) during tracheal intubation was greater (*P*<0.001) in Macintosh laryngoscope group than in Airtraq™ laryngoscope group.

Table 2 Patients and preoperative airway characteristics. Values are given as mean (SD) or number of patients except for age which is given as mean (range)

	Macintosh laryngoscope group, n=53	Airtraq™ laryngoscope group, n=53
Age (yr)	42 (26–58)	45 (21–66)
Gender (M/F)	13/27	10/30
ASA I/II/III	25/20/8	30/18/5
Body mass index (kg m ⁻²)	43 (5)	44 (6)
Thyromental distance (cm)	6.1 (0.6)	6.0 (1.0)
Interincisor distance (cm)	3.5 (0.4)	3.5 (0.5)
Mallampati score: 1,2,3,4	17/20/11/5	15/22/10/6

Table 3 Data on airway management in the two groups. The visual analogue scales for facemask ventilation and overall airway management difficulty range from 0 (very easy or no difficulty) to 100 (major difficulty or impossible). The visual analogue scale for sore throat intensity at discharge from the recovery room ranges from 0 (no pain) to 100 (worse imaginable pain). Visual analogue scale scores are given as median (range). Other values are given as mean (SD) or number of patients. **P*<0.05

	Macintosh laryngoscope group, n=53	Airtraq™ laryngoscope group, n=53
Visual analogue scale of facemask ventilation difficulty	26 (0–80)	23 (0–80)
Duration of tracheal intubation (s)	56 (23)	24 (16)*
Cormack and Lehane grade 1,2,3,4	18/24/10/1	53/0/0/0
Intubation difficulty score	5 (2–10)	0 (0–2)*
Intubation difficulty score >5	11	0*
Bispectral index during tracheal intubation	27 (13)	9 (16)*
Lowest arterial oxygen saturation (%)	95 (4)	96 (2)
Number of patients with arterial oxygen saturation ≤92%	9	1*
Visual analogue scale of overall airway management difficulty	24 (10–65)	12 (1–55)*
Visual analogue score of sore throat intensity	28 (0–70)	0 (0–30)*

Discussion

In this study, in morbidly obese patients the tracheal intubation time was shorter with the Airtraq™ laryngoscope than

Table 4 Intubation difficulty score for the two groups

	Macintosh laryngoscope group (n=53)	Airtraq™ laryngoscope group (n=53)
Number of patients in whom intubation required more than one operator	0	0
Number of patients in whom intubation required more than one attempt	4	0
Number of patients in whom alternative intubation techniques were used	17	0
Cormack and Lehane grade 1,2,3,4 (/number of patients)	18/24/10/1	53/0/0/0
Number of patients in whom increased lifting force required	22	4
Number of patients in whom laryngeal pressure was applied	31	1
Number of patients with vocal cord mobility	0	0

Table 5 Haemodynamic variations during tracheal intubation with the Macintosh and Airtraq laryngoscopes. MAP, mean arterial pressure (mm Hg); HR, heart rate (beats min⁻¹). Values are mean (SD). **P*<0.05

Laryngoscopes	Baseline	Just before insertion of the laryngoscope	During tracheal intubation	3 min after tracheal intubation
Macintosh				
MAP	96 (16)	72 (15)	97 (16)*	90 (14)*
HR	81 (14)	76 (12)	91 (17)*	77 (13)
Airtraq				
MAP	91 (18)	76 (19)	83 (20)*	76 (20)*
HR	82 (17)	78 (19)	79 (18)*	75 (19)

with the Macintosh laryngoscope. In addition, the Airtraq reduced the incidence of failure to intubate within 120 s and reduced the incidence of episodes of desaturation.

This is the first study to evaluate the Airtraq™ laryngoscope in morbidly obese patients and confirms our previous experience with this laryngoscope. We have recently shown that morbidly obese pregnant women could be intubated rapidly and safely with the Airtraq™ laryngoscope after failed attempts with the Macintosh laryngoscope.³

Obesity has been shown to be associated with increased risk of desaturation after induction of anaesthesia.⁸ It may be possible to reduce this risk by increasing the volume of pressurized oxygen trapped in the lung before attempting tracheal intubation,⁹ but rapid intubation will certainly help to avoid desaturation.

Our results support manikin studies of intubation with augmented tongue volume that have shown more rapid tracheal intubation with the Airtraq™ laryngoscope than with the Macintosh laryngoscope. During simulated augmented tongue volume, mean tracheal intubation duration at the first attempt using the Macintosh laryngoscope was twice that with the Airtraq™ laryngoscope.² This abnormal anatomical feature is common in morbidly obese patients and has been demonstrated in cephalometric studies.^{4,5}

The Airtraq™ laryngoscope has a thickness of 1.8 cm and a width of 2.8 cm. This was the reason for excluding patients with a mouth aperture of less than 3 cm. Intubation was easier in four patients when the Airtraq™ was inserted at an angle of 90° or more from that recommended (Fig. 2). The Airtraq™ was difficult to pass into the pharynx of 11 patients with the standard technique of insertion and tracheal intubation was considered traumatic in 10 patients. All of these patients were classified Mallampati 3 or more at the preoperative visit. Although we used small crawling movements for the standard intubation technique, as recommended by the inventor, intense pressure was often required to get the distal tip of the blade beyond the tongue. However, there was then an abrupt loss of resistance as the tip of the blade finally passed into the oropharyngeal space. The pressure required would explain the incidence of trauma associated with the Airtraq™ laryngoscope. We suggest that insertion of the Airtraq™ at 90° to the usual direction may be appropriate

when difficult intubation is expected because of a short chin-to-sternum distance, augmented tongue volume or because the neck is fixed in flexion.

Tracheal intubation of morbidly obese patients appears easier with the Airtraq™ laryngoscope than with the Macintosh laryngoscope. Difficult tracheal intubation as defined by an intubation difficulty score of greater than 5 was recorded in 11 patients of the Macintosh laryngoscope group, but no patients (intubation difficulty score >5) in the Airtraq™ group. Indeed, all patients of the Airtraq™ group were Cormack and Lehane grade 1 and none of them required a second attempt, an alternative technique of intubation, or the assistance of a second operator.

In our study, the Airtraq™ laryngoscope reduced haemodynamic stimulation resulting from airway management. This is consistent with the results of Maharaj and colleagues.¹⁰ This may be explained by the fact that the traction required to lift the mandible is reduced with the Airtraq™ laryngoscope. In addition, the passage of the tracheal tube through the vocal cords is atraumatic due to good glottic visualization and alignment of the tube to the axis of the trachea.

Our study has some limitations. We could not blind the observer collecting data, as his presence was required in the operating room for contemporaneous data collection. The evaluation of postoperative upper airway morbidity was not exhaustive. Indeed, we only assessed patients for the single symptom of sore throat using a visual analogue scale immediately before discharge from the recovery room. Although the limit of mouth opening for use of the Airtraq™ laryngoscope is about 2 cm due to its physical size, we chose to exclude patients with a mouth opening of less than 3 cm. In fact, no patients were excluded because of limited mouth opening. We suggest that an assessment of the Airtraq™ laryngoscope in patients with limited mouth opening would be valuable. Finally, we managed the airways of our patients laid on the operation table in a position that may impair conditions for tracheal intubation with the Macintosh laryngoscope but which favoured those for the Airtraq™. Indeed, some authors recommend a specific position for direct laryngoscopy with the Macintosh laryngoscope in morbidly obese patients.¹¹

We observed that tracheal intubation with the Airtraq™ laryngoscope was not impaired by the short chin-to-sternum distance often seen in morbidly obese patients, although the rotational manoeuvre was used in some patients. We believe that this may account in part for the advantage of the Airtraq™ laryngoscope over the Macintosh laryngoscope in morbidly obese patients.

In conclusion, we have demonstrated that the Airtraq™ laryngoscope achieves rapid and safe tracheal intubation of morbidly obese patients. We have shown that in this group of patients, the performance of this laryngoscope is superior to that of the standard Macintosh laryngoscope. However, there is an incidence of soft tissue trauma when

the Airtraq laryngoscope is used in this setting. We advise that patients should be warned about this before operation.

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