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Corresponding Author: Dr John G. Laffey, MD, MA, BSc, FFARCSI

Corresponding Author's Institution: National University of Ireland, Galway

First Author: Chrisen H Maharaj, MB, FFARCSI

Order of Authors: Chrisen H Maharaj, MB, FFARCSI; Martina Ni Chonghaile, MB, FCARCSI; Brendan D Higgins, PhD; Brian H Harte, MB, FFARCSI; John G. Laffey, MD, MA, BSc, FFARCSI

Abstract: The Airtraq® Laryngoscope is a novel intubation device which may possess advantages over conventional direct laryngoscopes for use by personnel that are infrequently required to perform tracheal intubation. We conducted a prospective study in 20 medical residents with little prior airway management experience. Following brief didactic instruction, each participant took turns performing laryngoscopy and intubation using the Macintosh and Airtraq® devices, in three laryngoscopy scenarios in a Laerdal® Intubation Trainer and one scenario in a Laerdal® SimMan® Manikin. They then performed tracheal intubation of the normal airway a second time to characterize the learning curve. In all scenarios tested, the Airtraq® decreased the duration of intubation attempts, reduced the number of optimization maneuvers required, and reduced the potential for dental trauma. The residents found the Airtraq® easier to use in all scenarios compared to the Macintosh laryngoscope. The Airtraq® may constitute a superior device for use by personnel infrequently required to perform tracheal intubation.

* Cover Letter

Feb 15, 2005

The Editor-in Chief,
American Journal of Emergency Medicine,

Re: Manuscript Submission – Maharaj et al

DR. JOHN G. LAFFEY,
MD, MA, BSc, FFARCSI

Consultant in Anesthesia and
Intensive Care Medicine,
Unicersity College Hospital,
Galway.

Clinical Lecturer in Anesthesia,
Clinical Sciences Institute,
National University of Ireland,
Galway.

Clinician Scientist,
National Centre for Biomedical
Engineering Sciences, NUI Galway.

DEPARTMENT OF ANAESTHESIA
Office: 091 - 54 – 4074
Laboratory: 091 - 54 – 4608
Fax: : 091 - 54 - 4908
Email: john.laffey@nuigalway.ie

Dear Editor,

Please find enclosed a manuscript entitled Tracheal intubation by inexperienced medical residents using the Airtraq® and Macintosh laryngoscope – A manikin study' by Maharaj et al for consideration for publication in The American Journal of Emergency Medicine. The authors wish to attest to the following points:

1. The manuscript, as submitted or its essence in another version, is not under consideration for publication elsewhere, and will not be published elsewhere while under consideration by *AJEM*.

2. All authors have made substantive contributions to the study, and all authors endorse the data and conclusions.

3. The authors have no commercial associations or sources of support that might pose a conflict of interest. Specifically, the authors have no relationship, financial or otherwise with the device or its manufacturers and do not stand to gain from any commercial success the Airtraq® device may achieve.

If you require any further details please do not hesitate to contact Dr Laffey, the corresponding author.

Yours Sincerely,

Dr Chrisen Maharaj

Dr Martina Ni Chonghaile

Dr Brendan Higgins

Dr Brian Harte

Dr John Laffey

*** Title Page**

Title: Tracheal intubation by inexperienced medical residents using the Airtraq® and Macintosh laryngoscope – A manikin study.

AUTHORS: Maharaj C.H. [1,2]
Ni Chonghaile, M.[1,2]
Higgins, B.D.[2]
Harte B.H. [1]
Laffey J.G. [1,2]

INSTITUTIONAL AFFILIATIONS

[1] Department of Anaesthesia, University College Hospital Galway, Ireland.

[2] Department of Anaesthesia, Clinical Sciences Institute, and National Centre for Biomedical Engineering Sciences, National University of Ireland, Galway, Ireland.

Address for Correspondence: Dr John Laffey, Department of Anaesthesia, Clinical Sciences Institute, National University of Ireland, Galway, Ireland.
john.laffey@nuigalway.ie

RUNNING HEAD: Tracheal intubation by Medical Residents

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INTRODUCTION

In the emergency setting, personnel with limited clinical experience in the skills of direct laryngoscopy may be required to perform tracheal intubation. Several studies have demonstrated improved outcome in critically injured patients if the airway is secured early by endotracheal intubation (1-3). However, difficult or failed tracheal intubation in this context constitutes an important cause of morbidity, arising from direct airway trauma and the systemic complications of hypoxia (4,5). Novel intubation devices may reduce the potential for morbidity arising from difficulties in tracheal intubation encountered by less experienced personnel.

The Airtraq® is a new intubation device that has been developed for the management of the normal and the difficult airway (**Figure 1**). It is designed to provide a view of the glottis without alignment of the oral, pharyngeal and tracheal axes. The blade of the Airtraq consists of two side by side channels. One channel acts as the housing for the placement and insertion of the endotracheal tube (ETT), while the other channel terminates in a distal lens (**Figure 2A**). A battery operated light is present at the tip of the blade. The image is transmitted to a proximal viewfinder using a combination of lenses and prisms, rather than fibre optics. The viewing lens allows visualization of the glottis and surrounding structures, and the tip of the tracheal tube (**Figure 2B**). The Airtraq® is anatomically shaped and standard endotracheal tubes of all sizes can be used. The blade is inserted into the mouth in the midline, over the base of the tongue, and the tip positioned in the vallecula, using the viewfinder to optimize the view of the glottis (**Figure 2C**). Once the view of the glottis has been optimized, the endotracheal tube is passed through the vocal cords, held in place, and the device removed (**Figure 2D**). A clear view of the glottis and ETT is maintained throughout

the intubation process and the ETT does not obstruct the view of the vocal cords (**Figure 3**).

Our group has recently demonstrated that Airtraq® device performs superiorly to the conventional Macintosh laryngoscope when used by experienced anesthesiologists in simulated difficult laryngoscopy (6). Notably, we observed a rapid learning curve for the device. Based on these findings we proposed that the Airtraq® may possess advantages over conventional laryngoscopes for use by less experienced personnel. The purpose of this study was to evaluate the usefulness of this new device for use by personnel with some, but limited prior experience of tracheal intubation, in anatomically correct manikins. We hypothesized that, in the hands of inexperienced laryngoscopists, the Airtraq® would be equal or superior to the Macintosh laryngoscope in the normal and simulated difficult airway.

METHODS

Following ethical committee approval, and written informed consent, 20 medical residents with some, but limited prior experience of performing tracheal intubation consented to participate. All participants had received prior training with the Macintosh laryngoscope, and performed duties on the trauma and/or cardiac arrest team when on call, but had performed less than 10 tracheal intubations at the time of recruitment into the study. Each resident was given a standardized ten minute demonstration of both the Macintosh, and the Airtraq® devices by one of the investigators, which included a demonstration of the intubation technique with each device, and oral instructions regarding the correct use of each device. The use of optimization maneuvers, such as external laryngeal pressure, to facilitate intubation with the Macintosh was also demonstrated. Each participant was then allowed five practice intubations with each device, at which stage all students could successfully perform tracheal intubation with both devices. All intubations were performed with a 7.5 gauge cuffed tracheal tube. The sequence in which each participant used the devices was randomized, and each participant used the devices in the same sequence throughout the protocol.

The design of the study was a randomized crossover trial. Each resident first performed tracheal intubation with each device in a Laerdal® Airway Management Trainer (Laerdal®, Stavanger, Norway) in the following laryngoscopy scenarios: (1) normal airway in the supine position; (2) normal airway in the left lateral position; and (3) cervical immobilization. The participants then performed tracheal intubation in a SimMan® manikin (Laerdal®, Kent, UK) in the (4) pharyngeal obstruction

difficult laryngoscopy scenario. At the end of this protocol, each subject performed tracheal intubation of the normal airway a second time in the Laerdal® Airway Management Trainer with each device in order to characterize the learning curve.

The primary endpoint was the duration of tracheal intubation attempts. The duration of each tracheal intubation attempt was defined as the time taken from insertion of the blade between the teeth until the ETT was deemed to be correctly positioned by each participant. Where the participant was unsure as to the position of the ETT, the time taken to connect the ETT to an Ambu® bag and inflate the lungs was also included in the duration of the attempt. In any case, after each intubation attempt an investigator verified the position of the ETT tip. A failed intubation attempt was defined as an attempt in which the trachea was not intubated, or where intubation of the trachea required greater than 120 seconds to perform.

Additional endpoints included the rate of successful placement of the endotracheal tube (ETT) in the trachea, the number of intubation attempts, the number of optimization maneuvers required (readjustment of head position, second assistant) to aid tracheal intubation and the severity of dental trauma. The severity of dental trauma was calculated based on the number of audible teeth clicks (0, 1 or >1) with the Laerdal airway trainer, and based on a grading of pressure on the teeth (none =0, mild =1, moderate/severe ≥2) in the SimMan manikin. At the end of each scenario, each participant scored the ease of use of each device on a visual analogue scale (from 0 = Extremely Easy to 10 = Extremely Difficult).

Data for duration of the first and the successful intubation attempt and the instrument difficulty score were analyzed using the t test. Data for the success of tracheal intubation attempts was analyzed using Chi square or Fishers exact test as appropriate. The number of intubation attempts, number of optimization manoeuvres, and severity of dental trauma was analyzed using the Mann Whitney Rank sum test. Continuous data are presented as means ± standard deviation (SD), and ordinal and categorical data are presented as number and as frequencies. The α level for all analyses was set as $P < 0.05$.

RESULTS

Twenty residents consented to participate in the study. All residents were in their second to fifth year of training, and no participant had previously performed more than 10 tracheal intubations.

Scenario 1 – Normal Airway at start of Protocol

The duration of both the first and the successful tracheal intubation attempts were significantly shorter with the Airtraq® compared to the Macintosh Laryngoscope (***Table 1 and Figure 4***). All residents successfully intubated the trachea with the Airtraq®, compared to 19 (95%) with the Macintosh laryngoscope (***Table 1***). All residents intubated the trachea on the first attempt with the Airtraq® laryngoscope, while 4 required more than one attempt with the Macintosh laryngoscope. The number of optimization maneuvers and the severity of dental trauma were significantly lower with the Airtraq® (***Table 1***). The participants found the Airtraq® significantly easier to use in this scenario (***Figure 5***).

Scenario 2 – Normal Airway with Head in Left Lateral Position

The duration of both the first and the successful tracheal intubation attempts were significantly shorter with the Airtraq® compared to the Macintosh Laryngoscope (***Table 2 and Figure 4***). Sixteen (80%) residents successfully intubated the trachea with the Airtraq®, compared to 10 (50%) with the Macintosh laryngoscope (***Table 2***). The number of intubation attempts, the number of optimization maneuvers and the severity of dental trauma were all significantly lower with the Airtraq® (***Table 2***). The participants found the Airtraq® significantly easier to use in this scenario (***Figure 5***).

Scenario 3 – Difficult Airway with Cervical Spine Rigidity

The duration of both the first and the successful tracheal intubation attempts were significantly shorter with the Airtraq® compared to the Macintosh Laryngoscope (***Table 3 and Figure 4***). Nineteen (95%) residents successfully intubated the trachea with the Airtraq®, compared to 15 (75%) with the Macintosh laryngoscope (***Table 3***). The number of intubation attempts, the number of optimization maneuvers and the severity of dental trauma were all significantly lower with the Airtraq® (***Table 2***). The participants found the Airtraq® significantly easier to use in this scenario (***Figure 5***).

Scenario 4 – Difficult Airway with Pharyngeal Obstruction

The duration of both the first and the successful tracheal intubation attempts were significantly shorter with the Airtraq® compared to the Macintosh Laryngoscope (***Table 4 and Figure 4***). All residents successfully intubated the trachea with the Airtraq®, compared to 18 (80%) with the Macintosh laryngoscope (***Table 4***). There was no difference in the number of intubation attempts, the number of optimization maneuvers required with each device. However, the severity of dental trauma was significantly lower with the Airtraq® (***Table 2***). The participants found the Airtraq® significantly easier to use in this scenario (***Figure 5***).

Scenario 5 – Normal Airway at end of Protocol

All students successfully intubated the trachea with on the first attempt with the Airtraq®, compared to 19 (95%) with the Macintosh laryngoscope (***Table 5***). The duration of intubation attempts with the Airtraq® was significantly shorter compared to that required at the start of the protocol, illustrating rapid skill acquisition for this

devices. In contrast, there was no difference in the duration of intubation attempts with the Macintosh laryngoscope compared to that required at the start of the protocol. Furthermore, the duration of the tracheal intubation attempts, and the severity of dental trauma was significantly shorter with the Airtraq® compared to the Macintosh Laryngoscope (***Table 5 and Figure 4***). The participants found the Airtraq® significantly easier to use than the Macintosh (***Figure 5***).

DISCUSSION

Several studies have demonstrated improved outcome in severely ill and injured patients if the airway is secured early by tracheal intubation (1-3). Medical personnel that are relatively inexperienced in the skills of direct laryngoscopy may therefore be required to perform tracheal intubation as a lifesaving maneuver in the emergency room or in the pre-hospital arena. However, tracheal intubation in these emergent situations poses particular difficulties. In the pre-hospital setting, tracheal intubation is more difficult to perform, with a lower success rate, particularly in inexperienced hands (7). The occurrence of difficulties and/or failure to successfully intubate the trachea constitutes an important cause of morbidity (4,5,8). The need for repeated attempts to secure the airway emergently increases airway-related complications such as hypoxia, pulmonary aspiration and adverse hemodynamic events (5). Of particular concern, accidental esophageal intubation in emergency situations outside the operating room results in high incidences of severe hypoxemia, regurgitation and pulmonary aspiration of gastric contents, cardiac dysrythmias and cardiac arrest (4). Difficulties in tracheal intubation may also result in severe local complications such as perforation of laryngeal or pharyngeal structures (9).

These difficulties have led several commentators to question the practice of pre-hospital tracheal intubation by personnel not fluent in the technique (10-12). A slow learning curve for intubation with the Macintosh blade has been well documented among paramedical personnel (13,14) due to lack of regular exposure to the technique. These difficulties have led to the increasing use of supraglottic devices (Combitube®, Laryngeal Tube® and Laryngeal Mask Airway®) for airway management in these contexts (15) (16,17), due to the rapid learning curves associated

with these devices (18,19). However trauma to the airway and aspiration injury remain a significant risk with these devices in these patients.

Many of the complications of tracheal intubation result from attempts, often multiple, to view glottic structures using rigid blades. Conventional direct laryngoscopic laryngoscopes, such as the Macintosh laryngoscope, require the alignment of oral and tracheal axes in order to view the glottic opening. This is a difficult skill to successfully acquire (12,13,20), and to maintain (14), particularly if the opportunities to practice this skill are limited, such as in the case of non-anesthesiologists required to perform tracheal intubation in emergency situations. This difficulty is further compounded by the fact that emergent tracheal intubation, e.g. in the pre-hospital setting, is more difficult to perform, with a lower success rate, particularly if performed by inexperienced personnel (7).

The Airtraq® device has the potential to reduce the morbidity arising from difficulties in tracheal intubation encountered by personnel infrequently required to perform tracheal intubation. It has an exaggerated curvature with enhanced optics that gives an excellent view of the glottis with minimal airway manipulation. The curved laryngoscope blade described by Macintosh in 1943 (21) remains the most popular device used to facilitate orotracheal intubation, notwithstanding recent developments in airway device technologies, it constitutes the gold standard. We therefore decided to compare the utility of the Airtraq® to the Macintosh laryngoscope for use by medical residents with limited airway management experience in two different

anatomically correct manikins, in four scenarios simulating easy and difficult laryngoscopy.

Our study demonstrates that, in comparison to the Macinotsh laryngoscope, the Airtraq® provides superior intubating conditions in the normal airway. All residents successfully intubated the normal airway with both devices in the final scenario. At the end of the protocol, the duration required for the intubation attempt was reduced significantly for the Airtraq®, but not the Macinotsh laryngoscope, illustrating the rapid learning curve with the Airtraq®. The Airtraq® device significantly reduced the duration of intubation, the requirement for maneuvers to optimize the laryngoscopic view obtained, and reduced the potential for dental trauma at both the start and at the end of the protocol.

The Airtraq® also provided superior intubating conditions in the simulated difficult airway, a scenario not uncommon outside the operating room where intubating conditions and assistance may be suboptimal. In the simulated difficult airway scenarios, the Airtraq® resulted in a higher percentage of successful intubations, reduced the time required to perform tracheal intubation, required fewer airway optimization maneuvers, and caused less dental trauma than the Macintosh Laryngoscope. Of particular interest, the duration of intubation attempts with the Airtraq® compared well with that recorded by experienced anesthesiologists in our recent study (6). This finding highlights the ease of use and the rapid learning curve associated with this device, for both experienced and inexperienced laryngoscopists. The medical residents also found the Airtraq® easier to use than the Macintosh

laryngoscope, as reflected in their lower Instrument Difficulty Score for the Airtraq® device.

The Airtraq® provides a high quality 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. Our present study attests to this, by the fact that, the dental trauma scores, were lower with the Airtraq® laryngoscope, particularly in the difficult airway scenarios. This may translate into a requirement for less operator skill to use this device compared to the Macintosh laryngoscope, leading to more rapidly acquired proficiency in personnel who are infrequently required to perform tracheal intubation, such as emergency room staff. That the device exhibits a rapid learning curve, despite a deliberately brief instruction period, supports this contention..

The Airtraq®, as a single-use device, removes the potential for transmission of prions, which are thought to be responsible for causing variant CJD (22,23). This complies with the guidelines of the Association of Anaesthetists of Great Britain and Ireland, which state that 'single use intubation aids' should be used where possible (24), due to difficulties in ensuring that all proteinaceous material has been removed during cleaning and sterilization (22,25).

In conclusion, the Airtraq® laryngoscope appears to possess advantages over the conventional Macintosh laryngoscope when used by inexperienced laryngoscopists. In this manikin study, the Airtraq® laryngoscope performed superiorly in both the normal and the difficult airway scenarios. Further clinical studies are necessary to confirm these initial positive findings.

ACKNOWLEDGEMENT

We would like to thank Prodol Ltd, for the provision of the Airtraq® device.

CONFLICT OF INTEREST

The authors have no conflict of interest in regard to the Airtraq® device.

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TABLE LEGENDS

Table 1: Data from easy laryngoscopy scenario at the start of the protocol in Laerdal® Airway Trainer.

Table 2: Data from laryngoscopy in left lateral position scenario in Laerdal® Airway Trainer.

Table 3: Data from Cervical Immobilization scenario in Laerdal® Airway Trainer.

Table 4: Data from Pharyngeal Obstruction scenario in SimMan® Manikin.

Table 5: Data from easy laryngoscopy scenario at the end of the protocol in Laerdal® Airway Trainer.

FIGURE LEGENDS

Figure 1: Photograph of the Aitraq® laryngoscope with a tracheal tube in place in the side channel.

Figure 2: Technique of tracheal intubation with the Aitraq® laryngoscope. The device is held in the left hand and the ETT inserted into the side channel (**Panel A**). The device is then passed into the mouth over the tongue, and the tip placed in the vallecula or under the epiglottis (**Panel B**). The glottis is then viewed through the viewfinder, and the view optimized if required by lifting the epiglottis by elevating the blade into the vallecula. Once the glottis is in the center of the view, the ETT is

then passed from its position in the channel through the vocal cords (**Panel C**). The cuff of the ETT can be viewed passing through the cords, and the position of ETT confirmed at the level of the cords The ETT is then moved laterally to remove it from the channel, the device is withdrawn, and the ETT secured (**Panel D**).

Figure 3: View of the glottis obtained during tracheal intubation with the Aitraq® laryngoscope.

Figure 4: Graph representing the duration required to successfully intubate the trachea with each device in each scenario tested. The data are given as mean ± SD.
* Indicates significantly different compared to the Macintosh Laryngoscope
Labels: Normal Airway – Start: Intubation of the normal airway at the start of the protocol; Left Lateral – intubation of the normal airway in the left lateral position; Cervical Immobilization– SimMan Cervical Spine Rigidity Scenario; Pharyngeal Obstruction – SimMan Pharyngeal Obstruction Scenario; Normal Airway – End: Intubation of the normal airway at the end of the protocol.

Figure 5: Graph representing the user rated degree of difficulty of use of each instrument in each scenario tested. The data are given as mean ± SD.
* Indicates significantly different compared to the Macintosh Laryngoscope
Labels: Normal Airway – Start: Intubation of the normal airway at the start of the protocol; Left Lateral – intubation of the normal airway in the left lateral position; Cervical Immobilization– SimMan Cervical Spine Rigidity Scenario; Pharyngeal Obstruction – SimMan Pharyngeal Obstruction Scenario; Normal Airway – End: Intubation of the normal airway at the end of the protocol.

Table(s)

Table 1 – Data from easy laryngoscopy scenario in Laerdal® Airway Trainer.

Parameter Assessed	Macintosh	Airtraq®
Overall Success Rate (%)	19 (95)	20 (100)
Duration (1st attempt)	36.0± 32.7	18.1 ± 6.7*
Number of Intubation Attempts (%)		
1	16 (80)	20 (100)
2	3 (15)	0
3	1 (5)	0
No of Optimization Maneuvers (%)		
0	16 (80)	20(100)
1	3 (15)	0
>1	1 (5)	0
Dental Trauma [Teeth Clicks] (%)		
0	6 (30)	18 (90)†
1	9 (45)	2 (10)
>1	5 (25)	0

Notes: Data are reported as mean ± SD or as number (percentage).
* Significantly [$P < 0.05$] different compared to the Macintosh laryngoscope.
† Significantly [$P < 0.01$] different compared to the Macintosh laryngoscope.

Table 2 – Data from laryngoscopy in left lateral position scenario in Laerdal® Airway Trainer.

Parameter Assessed	Macintosh	Airtraq®
Overall Success Rate (%)	10(50)	16(80)
Duration (1st attempt)	89.0 ± 44.0	44.3 ± 40.2†
Number of Intubation Attempts (%)		
1	7 (35)	15 (75)*
2	3 (15)	1 (5)
3	10 (50)	4 (20)
No of Optimization Maneuvers (%)		
0	7 (35)	18 (90)†
1	5 (25)	2 (10)
>1	8 (40)	0
Dental Trauma [Teeth Clicks] (%)		
0	3 (15)	15 (75)†
1	4 (20)	5 (25)
>1	13 (65)	0

Notes: Data are reported as mean ± SD or as number (percentage).
* Significantly [$P < 0.05$] different compared to the Macintosh laryngoscope.
† Significantly [$P < 0.01$] different compared to the Macintosh laryngoscope.

Table 3 – Data from Cervical Spine Immobilisation scenario in Laerdal® Airway Trainer.

Parameter Assessed	Macintosh	Airtraq®
Overall Success Rate (%)	15 (75)	19 (95)
Duration (1st attempt)	65.9 ± 50.8	30.8 ± 31.7*
Number of Intubation Attempts (%)		
1	11 (55)	18 (90)*
2	1 (5)	1 (5)
3	8 (40)	1 (5)
No of Optimization Maneuvers (%)		
0	11 (55)	20 (100)†
1	3 (15)	0
>1	6 (30)	0
Dental Trauma [Teeth Clicks] (%)		
0	4 (20)	18 (90)†
1	4 (20)	2 (10)
>1	12 (60)	0

Notes: Data are reported as mean ± SD or as number (percentage).
* Significantly [$P < 0.05$] different compared to the Macintosh laryngoscope.
† Significantly [$P < 0.01$] different compared to the Macintosh laryngoscope.

Table 4 – Data from Pharyngeal Obstruction scenario in SimMan® Manikin.

Parameter Assessed	Macintosh	Airtraq®
Overall Success Rate (%)	18 (90)	20 (100)
Duration (1st attempt)	35.0 ± 32.9	12.4 ± 5.5†
Number of Intubation Attempts (%)		
1	16 (80)	20 (100)
2	1 (5)	0
3	3 (15)	0
No of Optimization Maneuvers (%)		
0	14 (70)	20 (100)
1	3 (15)	0
>1	3 (15)	0
Dental Compression [Severity] (%)		
0	0	10 (50)†
Mild [+]	7 (35)	9 (45)
Severe [++]	13 (65)	1 (5)

Notes: Data are reported as mean ± SD or as number (percentage).
* Significantly [$P < 0.05$] different compared to the Macintosh laryngoscope.
† Significantly [$P < 0.01$] different compared to the Macintosh laryngoscope.

Table 5 – Data from easy laryngoscopy scenario at end of protocol in Laerdal® Airway Trainer.

Parameter Assessed	Macintosh	Airtraq®
Overall Success Rate (%)	19 (95)	20 (100)
Duration (1st attempt)	23.2 ± 24.6	10.0 ± 4.6*
Number of Intubation Attempts (%)		
1	18 (90)	20 (100)
2	1 (5)	0
3	1 (5)	0
No of Optimization Maneuvers (%)		
0	16 (80)	20 (100)
1	4 (20)	0
>1	0	0
Dental Trauma [Teeth Clicks] (%)		
0	11 (55)	20 (100)*
1	8 (40)	0
>1	1 (5)	0

Notes: Data are reported as mean ± SD or as number (percentage).
* Significantly [$P < 0.05$] different compared to the Macintosh laryngoscope.
† Significantly [$P < 0.01$] different compared to the Macintosh laryngoscope.

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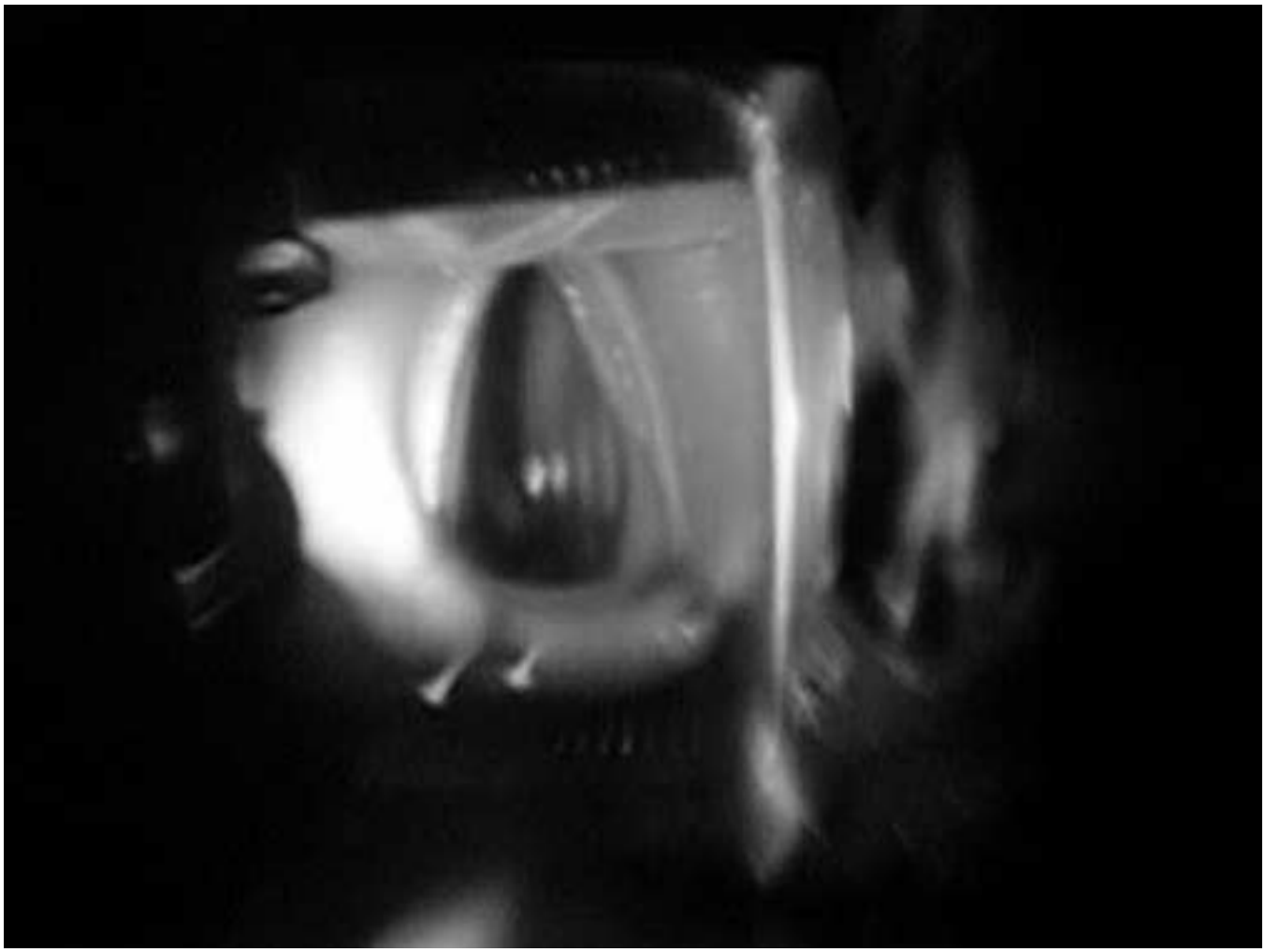

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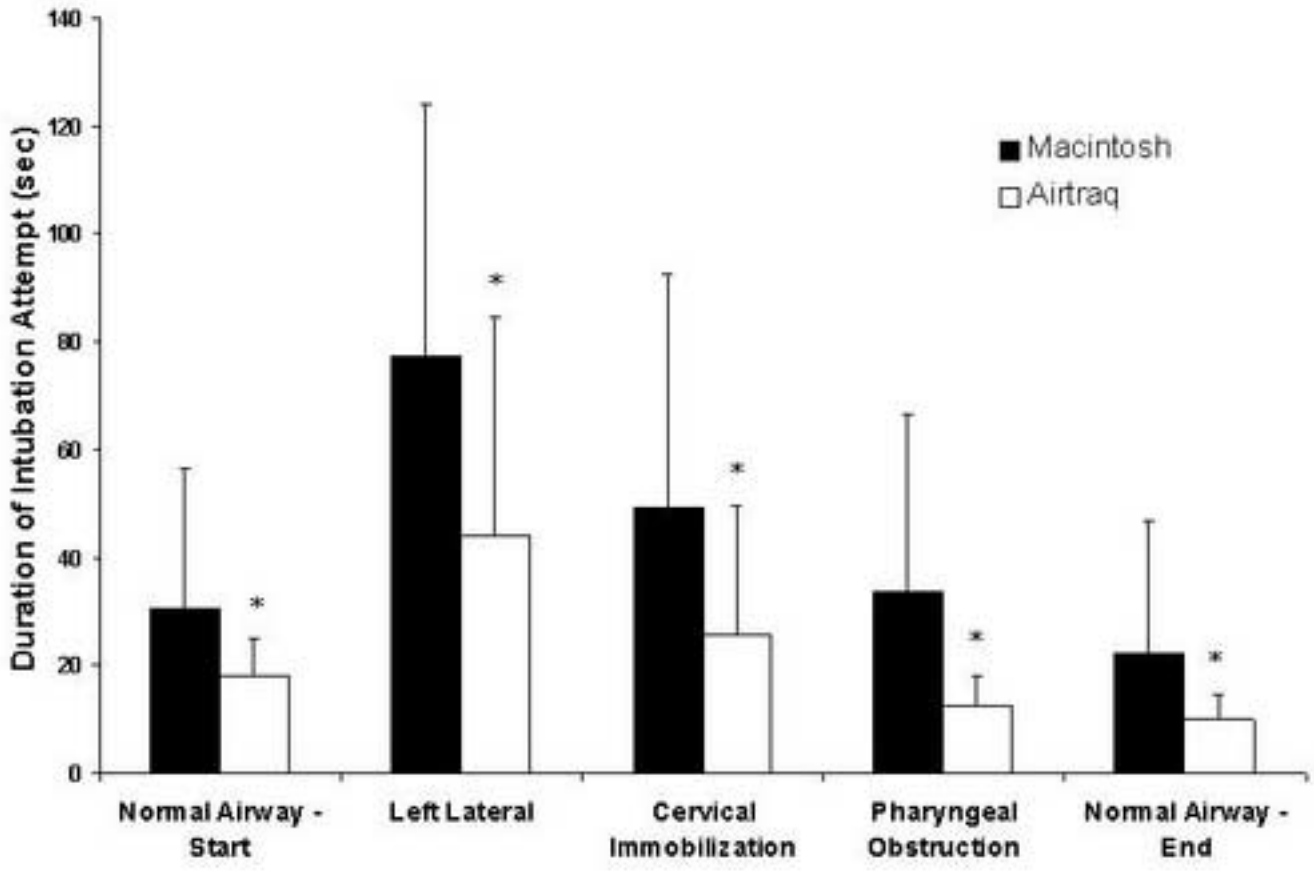

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