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ORIGINAL ARTICLE

Comparative evaluation of Airtraq™ and GlideScope® videolaryngoscopes for difficult pediatric intubation in a Pierre Robin manikin

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Abstract

Airway management in children is associated with anatomical and physiological challenges compared with adults. Pierre Robin sequence (PRS) is a condition characterized by micrognathia, glossoptosis, and cleft palate and related to a difficult airway. Both the Airtraq™ and GlideScope® have never been previously directly compared in PRS. Our aim was to evaluate the performance of these two airway devices in a PRS manikin for ethical and practical reasons. Between April and July 2017, 26, pediatric intensive care clinical fellows or trainees from a tertiary pediatric center were recruited to participate. In this prospective and randomized crossover trial, all participants first set up the Airtraq™ and the GlideScope® and then used these videolaryngoscopes to intubate an AirSim® PRS manikin. Our primary outcome measure was the duration of the successful intubation attempt. Duration of the successful intubation attempt was 18.1 (14.2–34.9 [10.2–51.3]) s for the Airtraq™ compared to 31.1 (18.7–55.6 [6.2–119]) s for the GlideScope® ($p = 0.045$). Setup time was 50.0 ± 6.9 s for the Airtraq™ and 27.8 ± 8.6 s for the GlideScope® ($p < 0.001$).

Conclusion: Even though setup time was longer, the characteristics of intubation performance were superior with the Airtraq™ relative to the GlideScope® in an AirSim® PRS manikin.

What is Known:
- *Several case reports have described the successful use of Airtraq™ to intubate children with Pierre Robin sequence.*
- *The GlideScope® has demonstrated similar rates of first-attempt successful intubation to flexible fiberoptic bronchoscopy in a Pierre Robin sequence manikin.*

What is New:
- *In the hands of pediatric non-airway specialists, the characteristics of intubation performance, including the duration of the successful intubation attempt, are superior with the Airtraq™ compared with the GlideScope® in a Pierre Robin sequence manikin.*
- *Setup time for the Airtraq™ is, however, longer relative to that for the GlideScope®.*

Keywords Intubation · Laryngoscopy · Manikins · Pediatrics · Pierre Robin syndrome

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Abbreviations

DL	Direct laryngoscopy
FFB	Flexible fiberoptic bronchoscopy
IQR	Interquartile range
NEAR4KIDS	National Emergency Airway Registry for Children
NHS	National Health Service
POGO	Percentage of glottic opening
PRS	Pierre Robin sequence
TTI	Time to intubation
SD	Standard deviation
VL	Videolaryngoscope

Introduction

Airway management in children is associated with anatomical and physiological challenges compared with adults [1, 2]. For pediatric patients without a specific syndrome, the incidence of difficult intubation has been reported as 0.03% [3]. In those pediatric patients with congenital syndromes or facial anomalies such as Pierre Robin sequence (PRS), characterized by micrognathia, glossoptosis, and cleft palate, the incidence of difficult intubation increases to 0.18% [4].

Conventional direct laryngoscopy (DL) can facilitate a view of the glottis and vocal cords if the oral, pharyngeal, and laryngeal axes are aligned. In children with a difficult airway, however, this is not always possible. Flexible fiberoptic bronchoscopy (FFB) is considered the criterion standard in children with an anticipated or known difficult airway [5], but is related to a long preparation time and the need for significant kinesthetic skill. Pediatric practice is therefore turning its attention to videolaryngoscopes (VL) which enable the operator to indirectly visualize the glottis and vocal cords without alignment of the various axes [6].

The Airtraq™ is a channeled, single use, and rigid optical laryngoscope which can be attached directly to a video camera device. It has a short learning curve, even for medical personnel inexperienced with laryngoscopy [7]. In comparison, the GlideScope® Advanced Video Laryngoscopy is composed of a reusable, flexible camera baton which is inserted into a disposable, plastic, and unchanneled 60°-curved blade and a connected portable video monitor (Fig. 1). Previous studies have demonstrated that the Airtraq™, in comparison with DL, is associated with improved laryngoscopic view, decreased time to intubation (TTI), increased intubation success rate, and reduced dental trauma score in pediatric difficult airway scenarios [8, 9]. Similar comparative studies have found the GlideScope® to result in a declined view to the glottic opening, an increased number of additional maneuvers, and either no difference or an increase in TTI [10–13]. None of these aforementioned trials, however, have been conducted in the setting of PRS.

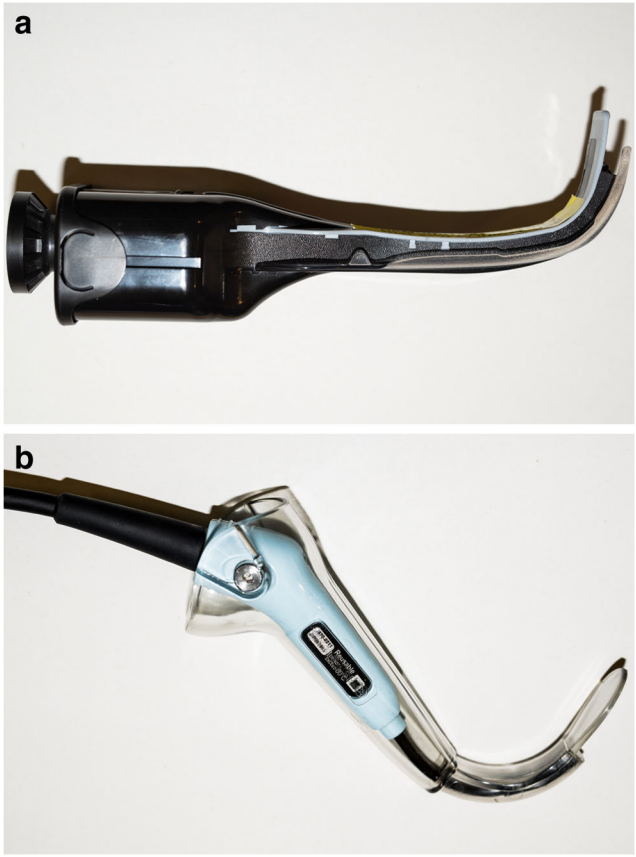

Fig. 1 Comparison of the two airway devices, **a** Airtraq™ and **b** GlideScope®, with obvious visual differences in design and angulation

Several cases describing the successful use of Airtraq™ to intubate children with PRS have been reported [14, 15] and the GlideScope® has shown similar rates of first-attempt successful intubation to FFB in a PRS manikin [16]. Both the Airtraq™ and the GlideScope® have never been directly compared in PRS, and, in view of this, we chose to undertake a pilot study to evaluate the performance of these two airway devices in a PRS manikin for ethical and practical reasons. Our primary outcome was the duration of the successful intubation attempt, and we hypothesized that no difference in performance would be found.

Materials and methods

It was decided that this study did not need formal ethical approval after consideration by the Joint Research and Development Office and it was registered as a service evaluation. Between April and July 2017, after written informed consent, all pediatric intensive care clinical fellows or trainees, with a background in pediatric training, from a tertiary pediatric center, Great Ormond Street Hospital for Children NHS Foundation Trust, were recruited to participate.

Before the study, all participants were asked to complete a questionnaire about their previous experience with the Airtraq™ and the GlideScope®. Each participant attended a standardized 45-min training session, which included an introduction to and demonstration of the setup, insertion technique, and use of the Airtraq™ SP with A-360 Wi-Fi camera (Prodol Meditec S.A., Vizcaya, Spain) and the GlideScope® Ranger (Verathon, WA, USA) in an AirSim® Pierre Robin manikin (TruCorp Limited, Belfast, Northern Ireland). Instructions were based on those from the literature supplied by the airway device manufacturers. All participants were subsequently provided with an opportunity to practice the set-up and intubation technique once with both airway devices.

In this prospective and randomized crossover trial, all participants first set up the Airtraq™ and the GlideScope® and then performed tracheal intubation with each assembled airway device (Fig. 2). Using the random number generator at http://www.random.org, a randomization list of airway device sequences for setup and tracheal intubation was generated. Setup and intubation attempts were monitored and timed.

For the Airtraq™, a gray-colored infant size 0 was selected and connected to a video camera device at its proximal end. A 3.5-mm internal diameter uncuffed Portex® tracheal tube (Smiths Medical International Limited, Kent, UK) was preloaded into the conduit channel. In the case of the GlideScope®, a size 2 single-use Stat blade, recommended for children with a weight of between 1.8–10 kg, was used. The distal end of the same size and type of tracheal tube was angulated with a Portex® 2-mm outer diameter malleable stylet (Smiths Medical International Limited, Kent, UK) to 60–90° in order to mimic the curve of this blade. All intubations were attempted on an AirSim® Pierre Robin manikin which is based on a 0–6-month old and constructed from real computed tomography data. It illustrates the various congenital defects of a pediatric patient with PRS including significant mandibular hypoplasia, glossoptosis, cleft palate, and a bifid uvula. Participants were not allowed to observe each other to avoid any learning effect.

Fig. 2 Demonstration of the view at videolaryngoscopy with the Airtraq™

Our primary outcome measure was the duration of the successful intubation attempt, recorded from the time taken from insertion of the airway device into the mouth to when the tip of the tracheal tube passed through the vocal cords. A failed intubation attempt was defined as one in which the trachea was not intubated within 120 s or if the airway device was removed from the mouth and repositioned. No more than three intubation attempts were permitted. Secondary outcome measures included the duration of setup, Cormack and Lehane grade of the first intubation attempt, percentage of glottic opening (POGO) score of the first intubation attempt [17], duration of the first intubation attempt, first intubation success, number of intubation attempts required, number of successful intubations performed in under 30 and 60 s and the number of esophageal intubations. Subjective secondary outcome parameters, graded by the participants, were the ease of setup, ease of insertion into the oropharynx, quality of view, and the ease of tube advancement for the two airway devices; all were graded as excellent, good, fair, or poor.

Statistical methods

Data analysis was carried out using statistical software SPSS (version 23, IBM Corp, Troy, NY, USA). Each variable was tested for normality with the Shapiro-Wilk test and has been presented as mean (± SD) if normally distributed and median (IQR [range]) if non-normally distributed. For univariate analyses, normally distributed variables were compared with the paired *t* test and non-normally distributed variables were compared with the Wilcoxon signed rank test. All comparison tests were conducted at the 5% significance level. In the absence of any prior sample data concerning the duration of the successful intubation attempt with each airway device when undertaken by non-anesthetists in PRS, a prospective sample size calculation was not performed.

Results

In all, 26 pediatric intensive care clinicians were recruited. Of these, 17 (65%), 1 (4%), and 8 (31%) were clinical fellows, speciality trainee grade 1–2, and speciality trainee grade 6–8, respectively. Fifteen (58%) participants had previous

experience of the Airtraq™ compared with 13 (50%) who had prior experience of the GlideScope®. No significant difference was found in this regard ($p = 0.527$). They had previously used the Airtraq™ and GlideScope® 1 (0–2 [0–10]) and 0.5 (0–2 [0–10]) times, respectively. All of those recruited, apart from one clinical fellow who failed to intubate with the GlideScope® in the maximum of three intubation attempts, were able to successfully intubate with both airway devices.

Our primary outcome measure, duration of the successful intubation attempt, was 18.1 (14.2–34.9 [10.2–51.3]) s for the Airtraq™ relative to 31.1 (18.7–55.6 [6.2–119]) s for the GlideScope® ($p = 0.045$). Comparison of secondary outcome measures demonstrated that the duration of setup was significantly longer for the Airtraq™ compared to the GlideScope® ($p < 0.001$) (Table 1). No differences between the airway devices in the Cormack and Lehane grade ($p = 0.18$) or POGO score ($p = 0.732$) of the first intubation attempt were revealed. Relative to the GlideScope®, the Airtraq™ was shown to be superior in terms of the duration of the first intubation attempt ($p = 0.001$), first intubation success ($p = 0.005$), the number of intubation attempts required ($p = 0.007$), and successful intubations performed in under 30 s ($p = 0.035$) and 60 s ($p = 0.025$). Subjective grading of the airway device setup ($p = 0.71$) and insertion ($p = 0.302$) did not differ between the Airtraq™ and the GlideScope®, but the quality of view ($p = 0.002$) and ease of tube advancement ($p < 0.001$) were preferentially rated in the Airtraq™ (Table 2). No esophageal intubations occurred with either airway devices.

Discussion

In the last few years, there has been a proliferation of new airway devices marketed for pediatric use, many of which represent scaled down versions of their adult counterparts [18]. Detailed examination of their designs is needed as pediatric airway anatomy is different to that of adults. In comparing the performance of the Airtraq™ and the GlideScope® in an AirSim® Pierre Robin manikin, our main finding was that the Airtraq™ was associated with a shorter duration of the successful intubation attempt.

Setup of the Airtraq™ requires consideration of a greater number of individual steps and is delayed by a prolonged start up time before becoming fully operational compared with the GlideScope®. It was not therefore unexpected that the time for setup of the GlideScope® was found to be relatively shorter. In the case of an anticipated difficult airway, where adequate preparation can be undertaken, or an unanticipated difficult airway, where oxygenation and ventilation is straightforward, a lengthier time for airway device setup could be less of a matter of concern. If oxygenation and ventilation is problematic, however, in the context of an unanticipated difficult airway, the VL with the shortest and simplest setup would be preferred.

Established by the American Academy of Pediatrics and the American Heart Association, the Neonatal Resuscitation Program recommends an intubation time of 20 s or less. Median duration of the successful intubation attempt was within this time frame for the Airtraq™ but not the GlideScope®. Use of the GlideScope® could hence cause a longer interruption of oxygenation and ventilation and a consequent increased likelihood of oxygen desaturation in a neonate or infant. In an analysis of the National Emergency Airway Registry for Children (NEAR4KIDS), a multicenter observational tracheal intubation database, oxygen desaturation to a saturation less than 80% was associated with adverse hemodynamic events, like dysrhythmia, hypotension, or hypertension needing intervention and cardiac arrest, and longer mechanical ventilation in critically ill children [19, 20].

It is not just the duration of the successful intubation attempt which is of interest. If first-attempt intubation is not successful, subsequent repeated intubation attempts can be related to complications such as airway trauma, hypoxia, vomiting and pulmonary aspiration, esophageal intubation with delayed recognition, the situation of "can't intubate can't ventilate," and cardiac arrest [21]. Compared with the GlideScope®, the Airtraq™ demonstrated superior characteristics of first-attempt intubation and required a fewer number

Table 1 Objective secondary outcome measures

Outcome measure	Airtraq™ ($n = 26$)	GlideScope® ($n = 26$)	p value
Setup time; seconds	50.0 (± 6.9)	27.8 (± 8.6)	< 0.001
First-attempt Cormack and Lehane grade; 1/2/3/4	20/6/0/0 (77/23/0/0%)	23/3/0/0 (88/12/0/0%)	0.18
First-attempt percentage of glottic opening score; 0–100	100 (95–100 [70–100])	100 (100–100 [50–100])	0.732
Duration of first intubation attempt; seconds	19.5 (14.2–30.6 [10.2–51.2])	46.9 (22.4–68.4 [9.3–120])	0.001
First intubation success; number	25 (96.2%)	17 (65.4%)	0.005
Number of intubation attempts required; 1/2/3	25/1/0 (96/4/0%)	17/8/0 (68/32/0%)	0.007
Successful intubations performed in under 30 s; number	18 (69.2%)	12 (48%)	0.035
Successful intubations performed in under 60 s; number	26 (100%)	20 (80%)	0.025

Data are presented as mean (± SD), median (IQR [range]) or number (%) depending on variable type

Table 2 Subjective secondary outcome measures

Outcome measure	Airtraq™ ($n = 26$)	GlideScope® ($n = 26$)	p value
Ease of airway device setup; excellent/good/fair/poor	13/10/2/1 (50/38/8/4%)	13/11/2/0 (50/42/8/0%)	0.71
Ease of airway device insertion; excellent/good/fair/poor	10/12/4/0 (38/46/15/0%)	8/11/7/0 (31/42/27/0%)	0.302
Quality of view; excellent/good/fair/poor	16/10/0/0 (62/38/0/0%)	6/13/7/0 (23/50/27/0%)	0.002
Ease of tube advancement; excellent/good/fair/poor	15/11/0/0 (58/42/0/0%)	2/11/12/1 (8/42/46/4%)	< 0.001

Data are presented as number (%)

of intubation attempts to succeed. Differences in intubation performance may be explained if, despite the equivalence in participant previous experience of the two airway devices, the learning curves for the Airtraq™ were to be more acute than that for the GlideScope®. In addition, the Airtraq™ was found to provide a quality of view of the glottis which was felt to be better, even though the extent of glottic visualization at first-attempt intubation was similar between the Airtraq™ and the GlideScope®. Characteristics of the design specific to the VLs may explain these results further. In contrast to the Airtraq™, which is channeled for the purposes of directing the tracheal tube into the correct location, the GlideScope® is unchanneled and mismatch of the angle of the stylet to the laryngeal inlet could result in a prolonged or failed intubation attempt. Consistent with this, subjective grading of the ease of tube advancement was inferior for the GlideScope®. Use of the pediatric Gliderite® Stylet, which complements the angle of the GlideScope®, may facilitate easier placement of the tracheal tube and improved intubation performance. It was not used in this study as it had only just been introduced and was not in widespread clinical use. In the adult setting, however, the standard malleable stylet has been shown to be as effective as the dedicated GlideScope® rigid stylet in terms of the TTI and perceived ease of intubation [22].

In accordance with our results and outside the context of PRS, two previous studies have demonstrated the Airtraq™, compared to the GlideScope®, to be associated with a decreased TTI in pediatric manikins with normal and difficult airways [23, 24]. Comparison of the two airway devices in a pediatric manikin with tongue edema, in contrast, revealed a similar intubation time but greater intubation success and a lower number of intubation attempts with the GlideScope® [25]. In a retrospective analysis of pediatric patients with a documented difficult airway, in whom over a third had micrognathia, first intubation success was 53% with the Airtraq™ relative to 35% with the GlideScope®, despite the operating anesthetists reporting less experience with the former [26]. Complications secondary to the use of the VLs included desaturation (7% vs 30%), airway bleeding (0% vs 5%), soft tissue damage (11% vs 10%), and esophageal intubation (7% vs 5%) for the Airtraq™ and GlideScope®, respectively. Successful use of the Airtraq™ to intubate a newborn with PRS has recently been reported after failed intubation attempts with direct laryngoscopy, the GlideScope® and the Pentax Airway Scope® [27]. Airway device performance could depend on the exact circumstances of the difficult airway, and the optimal VL may differ for various types of difficult airway situations [28].

The AirSim® manikin provided a standardized model of PRS and difficult laryngoscopy to facilitate the comparison of the VLs. It has previously been suggested to represent an excellent pediatric model for intubation of the difficult airway [16], although studies still need to be conducted to validate this. Outcomes during difficult airway management in humans are influenced by patient, airway device, and provider factors but the static manikin model removed the variability in patient factors. It thus allowed us to focus on the airway device and provider. Manikins, however, do not simulate human airway reactivity, movement, and secretions; may not precisely reproduce the pediatric difficult airway [29, 30]; and might not stimulate the operator stress usually associated with such situations. In particular, even though the Airtraq™ is relatively bulkier, the ease of VL insertion did not differ between the Airtraq™ and GlideScope® and could reflect an artifact of the manikin model. In view of this, we acknowledge that the findings from our manikin study may not be immediately translatable to outcomes in children, but a similar randomized controlled trial in pediatric patients with PRS would be precluded by ethical and practical considerations.

One of the potential limitations of our study was the definition of a failed intubation attempt which could have increased the first intubation success and decreased the number of intubation attempts required. It was possible, however, to elucidate the number of successful intubations performed in under 30 and 60 s from the secondary outcomes. Given the study was planned as a pilot, a sample size calculation was not performed and the sample size was small. Despite this, the sample size was still large enough to detect a statistically significant difference in outcomes. Our participants and investigators were not blinded to the intervention and so the findings could be subject to detection bias, though unlikely as the outcome measures were objective in nature. Last, as our participants were pediatric intensive care clinical fellows or trainees, with a background in pediatric and intensive care training, and

not necessarily airway experts, the results may have been different had the intubators been pediatric airway specialists. It should be noted, however, that the majority of clinicians in pediatric intensive care in the UK are in fact pediatricians, rather than anesthetists, with 6 months of exposure to adult anesthesia.

In conclusion, we showed that the setup time for the Airtraq™ was longer compared with that for the GlideScope® but the characteristics of intubation performance, including the duration of the successful intubation attempt, were superior with the Airtraq™ when used by pediatric intensive care clinical fellows or trainees in a PRS manikin.

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Compliance with ethical statements

Conflict of interest The authors declare that they have no conflicts of interest.

Ethical approval No formal ethical approval needed after consideration by the Joint Research and Development Office, and it was registered as a service evaluation.

Informed consent Written informed consent was obtained from all individual participants included in the study.

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