Masked Laryngeal Airways

Clinical Studies

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A randomised comparison of the self-pressurised air-Q™ intubating laryngeal airway with the LMA Unique™ in children

N. Jagannathan; L.E. Sohn; A. Sawardekar; R. Shah; K. Ryan; R. Jagannathan; K. Anderson (Profiled Authors: Lisa Sohn; Amod Sawardekar; Ravi Dipak Shah; Narasimhan Jagannathan)


Abstract

We conducted a randomised trial comparing the self-pressurised air-Q™ intubating laryngeal airway (air-Q SP) with the LMA-Unique in 60 children undergoing surgery. Outcomes measured were airway leak pressure, ease and time for insertion, fiberoptic examination, incidence of gastric insufflation and complications. Median (IQR [range]) time to successful device placement was faster with the air-Q SP (12 (10-15 [5-18])) s than with the LMA-Unique (14 (12-17 [6-22])) s; p = 0.05. There were no statistically significant differences between the air-Q SP and LMA-Unique in initial airway leak pressures (16 (14-18 [10-29]) compared with 18 (15-20 [10-30]) cmH 2O, p = 0.12), an airway leak pressures at 10 min (19 (16-22 [12-30]) compared with 20 (16-22 [10-30]) cmH 2O, p = 0.81); fiberoptic position, incidence of gastric insufflation, or complications. Both devices provided effective ventilation without the need for airway manipulation. The air-Q SP is an alternative to the LMA-Unique should the clinician prefer a device not requiring cuff monitoring during anaesthesia. © Anaesthesia © 2012 The Association of Anaesthetists of Great Britain and Ireland.
A Comparison of the Intubating Laryngeal Airway™ (ILA) with the Laryngeal Mask Airway™ (LMA)

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The Cookgas® Intubating Laryngeal Airway™ (ILA) is a new supraglottic airway, and is designed for smoother insertion into the airway and to allow easier insertion of an endotracheal tube through the device. This study is designed to test if indeed the ILA provides smoother insertion into the airway. In this study, the ease of insertion by experienced anesthesiologists using the ILA was compared to ease of insertion by experienced anesthesiologists using the Laryngeal Mask Airway Classic™ (LMA). We hypothesize that ease of insertion is no different for either device. This was a prospective, randomized, controlled trial of healthy adult patients (ASA physical status I or II) undergoing general anesthesia for elective surgery. Patients with a history of reflux, hiatal hernia, morbid obesity (BMI > 40), previous upper gastrointestinal surgery, and taking proton pump inhibitors or H2 antagonists were excluded. We measured supraglottic airway placement time, number of attempts to place the airway, and airway pressure at first audible leak after initial insertion and 5 min after the start of surgery. After surgery, the incidence and severity of sore throat was evaluated. A linear, mixed model analysis for repeated measures was used to compare airway pressures at initial insertion and at 5 min. The one-tailed test of equivalence was used to compare insertion times. The Wilcoxon rank-sum test was used to compare number of attempts to place the airway and occurrences of sore throat. The average ± SD placement time for the ILA and LMA was 20 ± 11 and 19 ± 8 seconds, respectively. There was no difference in placement time, number of attempts to place the airway, and sore throat (see figure) between the two devices. Overall there was no significant difference between the ILA and LMA in airway seal pressures, although, for the LMA, seal pressure significantly increased from 22.2 ± 4.9 cm H2O just after placement to 24.5 ± 5.2 cm H2O at 5 minutes after the start of surgery (P = 0.005). This finding warrants further study. We conclude that ease of insertion by experienced anesthesiologists is no different for the ILA compared to the LMA.

Anesthesiology 2006; 105: A1283

Figure 1

sore Throat Incidence

![Sore Throat Incidence Graph](image-url)
Case report

The new air-Q™ intubating laryngeal airway for tracheal intubation in children with anticipated difficult airway: a case series

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Summary

The air-Q intubating laryngeal airway (ILA) is a new supraglottic airway device which may overcome some limitations inherent to the classic laryngeal mask airway for tracheal intubation. We present a case series of patients with anticipated difficult airway in whom the air-Q ILA was successfully used as a conduit for fiberoptic intubation.

The laryngeal mask airway (LMA™; LMA North America, Inc., San Diego, CA, USA) has been demonstrated to be effective as a conduit for tracheal intubation in pediatric patients with a difficult airway (1–4). Although development of the LMA-Fastrach™ and LMA-CTrach™ have facilitated LMA-assisted tracheal intubations in both elective and emergent difficult airway scenarios in adults, such advancements have not yet been available for children. The main advantages of LMA-assisted tracheal intubation are (i) ease of placement, (ii) reliable alignment of the glottic opening, (iii) the ability to continuously oxygenate and ventilate, and (iv) minimizing disconnection time from the breathing circuit (5). However, utilizing the classic LMA for tracheal intubation in neonates and children has some limitations, and modification of the LMA and/or tracheal tube (TT) may have to be made for a successful intubation (1,6,7).

The air-Q ILA™ intubating laryngeal airway (ILA) (Cookgas, St. Louis, MO, USA), a new supraglottic airway device, may overcome these limitations inherent to the classic LMA for tracheal intubation. Advantages of the air-Q ILA over the classic LMA include: (i) a shorter, more curved shaft, (ii) an easily removable airway adapter, (iii) lack of a grill in the ventilating orifice, and (iv) the ability to remove the laryngeal airway after tracheal intubation with or without a stabilizing rod. (Figure 1) We present a case series of patients with anticipated difficult airway in whom the air-Q ILA was successfully used as a conduit for fiberoptic intubation.

Case report

Patient no. 1

A 2-year-old boy with Hurler’s syndrome was to undergo ventriculo-peritoneal shunt revision. Two months earlier, the patient had been difficult to ventilate after inhalation induction. A Cormack and Lehane Grade IV (C&L IV) was noted upon direct laryngoscopy. Subsequently, a no. 2 classic LMA was placed revealing a C&L II view of the glottis through a fiberoptic bronchoscope, and the patient was successfully intubated with a 4.0 uncuffed TT via the no. 2 LMA. Current airway examination
revealed a limited oropharyngeal space secondary to mucopolysaccharide deposits resulting in a mouth opening of 12 mm. Intramuscular ketamine 3 mg·kg⁻¹ was administered, and intravenous (IV) access was established. When positive pressure ventilation was adequate, paralysis was instituted with rocuronium. A size 1.5 air-Q ILA was inserted with a leak pressure of 24 cm H₂O followed by fiberoptic-assisted tracheal intubation with a 4.0 mm ID cuffed TT.

Patient no. 2

A 2-year-old girl with a large bilateral maxillo-mandibular dysplastic mass presented for excision. Interval computerized tomography (CT) scans revealed an expanding fibrous mass involving both the maxilla and the mandible. Previous anesthetic records documented an easy mask induction and placement of a no. 1.5 LMA for the CT scans. Her mouth opening was now less than 2 cm. Inhalation induction was performed with sevoflurane in oxygen, and positive pressure ventilation was instituted. IV access was obtained and paralysis was established with rocuronium. An air-Q ILA size 1.5 was inserted with a leak pressure of 24 cm H₂O followed by fiberoptic-assisted tracheal intubation with a 4.0 mm ID cuffed TT.

Patient no. 3

A 6-year-old boy with Treacher-Collins syndrome was to undergo dental extractions. For a previous mandibular distraction surgery, mask ventilation was noted to be easy and an oral fiberoptic intubation was successfully accomplished using an Olympus™ LF-P (Olympus America Inc., Center Valley, PA, USA), although difficult secondary to a large epiglottis. Airway examination revealed a mouth opening of 13 mm with significant micrognathia. Anesthesia was the same as described above for patient no. 2. An air-Q ILA size 1.5 was placed without difficulty, with a leak pressure of 30 cm H₂O and the patient was intubated with a 5.0 ID cuffed TT using a fiberoptic scope.

Patient no. 4

A 7-year-old boy with Goldenhar syndrome was scheduled for mandibular distraction. Prior history was significant for easy mask ventilation, but limited visualization by direct laryngoscopy (C&L III) and difficult tracheal intubation. Airway examination revealed a limited mouth opening of 15 mm and micrognathia. The patient was sedated with 70% nitrous oxide in oxygen and an IV was placed. Anesthetic induction was achieved with propofol. Rocuronium was administered once positive pressure ventilation was verified. An air-Q ILA size 2 was placed with a leak pressure of 26 cm H₂O and the patient was intubated with a 5.5 ID cuffed TT and a fiberoptic scope.

Patient no. 5

A 16-month-old girl with Hunter’s syndrome presented for magnetic resonance imaging of the brain and spine. At 10 months of age she was found to have limited visualization upon direct laryngoscopy (C&L IV). She was a difficult intubation and was intubated with a fiberoptic scope with a 3.5 uncuffed TT through a no. 1.5 LMA (C&L II view) for a ventriculo-peritoneal shunt placement. Present airway examination revealed a limited oropharyngeal space due to mucopolysaccharide deposits. Anesthesia was the same as described above for patient no. 1. A size 1 air-Q ILA was placed with a leak pressure of 28 cm H₂O and the patient was
intubated with a 4.0 mm ID cuffed TT using a fiberoptic scope.

**Technique for securing the airway**

All patients received 10 mcg·kg⁻¹ of IV glycopyrrolate to minimize secretions after vascular access was established. The air-Q ILA was deflated and inserted using a rotational technique. The cuff of the air-Q ILA was inflated according to the manufacturer’s instructions: Size 1 required <3 ml, size 1.5 required <5 ml, and size 2 required 5–10 ml. Our goal was to achieve a minimum leak of 20 cm H₂O while staying within the manufacturer’s guidelines for cuff inflation. Leak pressures were obtained by auscultation over the anterior neck while observing the ventilator manometer during a positive pressure breath. After this determination, mechanical ventilation of about 10 ml·kg⁻¹ using pressure-limited ventilation was instituted. The airway adapter of the air-Q ILA was removed prior to proceeding with a fiberoptic-assisted intubation. With an Olympus™ LF-DP fiberoptic scope (3.1 mm OD) (Olympus America Inc., Melville, NY, USA), a TT was loaded on to the fiberoptic scope prior to insertion into the trachea. The patients were then ventilated through the TT still within the air-Q ILA to verify bilateral breath sounds and endtidal carbon dioxide. The air-Q ILA was easily removed without the aid of a ‘pusher’ or stabilizing rod after intubation. Removal of the air-Q ILA required: (i) removal of the TT adapter, (ii) complete deflation of the air-Q ILA, (iii) downward traction on the TT, and (iv) distal control of the TT with the forefinger and thumb, while withdrawing the laryngeal airway. At the end of surgery, all patients were successfully extubated over an airway exchange catheter (AEC) (Cook Medical; Bloomington, IN, USA). Table 1 summarizes the cases and patient characteristics.

**Discussion**

Although the classic LMA has been a cornerstone in the management of the difficult pediatric airway, there are some limitations when it is used as a conduit for intubation. First, the shaft of the LMA can be as long as the TT making it difficult to maintain control of the TT while removing the LMA. Either a long tracheal tube (8), a double tracheal tube assembly (6,7,9), or a stabilizing rod is required to overcome the length of the LMA. A stabilizing rod is not available for the classic LMA as is seen with the adult ILMA’s. These methods can be utilized to decrease the likelihood of accidental extubation of the TT during removal of the LMA. Shortening the shaft of the LMA (10) or leaving the LMA in place (4,11) for the duration of surgery have also been suggested to minimize these potential risks. Second, the airway connector of the LMA is not wide enough to allow passage of the cuffed TT pilot balloon. This would result in the pilot balloon ‘hanging up’ within the shaft of the LMA and potentially breaking upon attempted withdrawal of the LMA (9). Third, when using disposable LMA’s, the grill may have to be cut to permit a larger or cuffed TT when compared with its nondisposable counterpart (12) (Table 2).

**Table 1**

Patient characteristics and a comparison of maximum tracheal tube (TT) sizes in the air-Q intubating laryngeal airway (ILA)™ vs the classic laryngeal mask airway (LMA)™

<table>
<thead>
<tr>
<th>Patient (no.)</th>
<th>Age (y)</th>
<th>Weight (kg)</th>
<th>Cause of difficult airway</th>
<th>Mouth opening between incisors (mm)</th>
<th>Size of air-Q ILA™ placed</th>
<th>Leak pressure (cm H₂O) after air-Q ILA™ placement</th>
<th>Cuffed TT size placed (mm ID)</th>
<th>Maximum cuffed TT size (mm ID) permitted by the air-Q ILA™</th>
<th>Maximum uncuffed TT size (mm ID) permitted by the same sized LMA™</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>12</td>
<td>Hurler’s syndrome</td>
<td>12</td>
<td>1.5</td>
<td>24</td>
<td>4.0</td>
<td>5.0</td>
<td>4.0</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>16</td>
<td>Maxillo-mandibular mass</td>
<td>20</td>
<td>1.5</td>
<td>30</td>
<td>4.5</td>
<td>5.0</td>
<td>4.0</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>22</td>
<td>Treacher-Collins syndrome</td>
<td>13</td>
<td>1.5</td>
<td>26</td>
<td>5.0</td>
<td>5.0</td>
<td>4.0</td>
</tr>
<tr>
<td>4</td>
<td>7</td>
<td>27</td>
<td>Goldenhar syndrome</td>
<td>15</td>
<td>2</td>
<td>26</td>
<td>5.5</td>
<td>5.5</td>
<td>4.5</td>
</tr>
<tr>
<td>5</td>
<td>16</td>
<td>10</td>
<td>Hunter’s syndrome</td>
<td>16</td>
<td>1</td>
<td>28</td>
<td>4.0</td>
<td>4.0</td>
<td>3.5</td>
</tr>
</tbody>
</table>

kg, kilogram; mm, millimeters; ID, internal diameter; y, year; m, months.
The Air-Q ILA has several key structural differences from the classic LMA; therefore, it has the potential to overcome the limitations of the classic LMA. As the shaft of this airway is much shorter and curved, enough of the proximal TT is still above the shaft, allowing for removal of the Air-Q ILA without the aid of a stabilizing rod. If desired, the clinician can easily remove the Air-Q ILA using a specially designed removal stylet to prevent dislodging the TT. In our series, we were able to remove the Air-Q ILA without the use of this stylet to stabilize the TT in the larynx. The airway connector of the Air-Q ILA is easily removable eliminating this potential area where the pilot balloon of the TT can get stuck. A grill is not present in the Air-Q ILA and pediatric sizes 1, 1.5, 2, 2.5, 3.5, and 4.5 can accommodate up to cuffed TT sizes 4.0, 5.0, 5.5, and 6.0 mm ID respectively. This issue is clinically applicable in patients with a limitation in mouth opening in whom only smaller laryngeal airways may fit while still needing to place a size appropriate cuffed TT.

We found the rotational insertion technique of the deflated Air-Q ILA the most successful. Prior to conducting this case series, we placed several Air-Q ILA’s electively in children with normal airways and found this to be easiest. In all our patients the TT was inserted into the trachea on the first attempt with no decrease in oxygen saturation. An AEC was placed through the TT prior to extubation as a means to re-intubate if needed. The AEC was removed when the patient exhibited adequate respiratory effort, facial grimacing, and hip flexion. There were no postoperative airway complications in any of the patients.

The Air-Q ILA is available in six sizes (1, 1.5, 2, 2.5, 3.5, 4.5) for single use and four sizes (2.0, 2.5, 3.5, and 4.5) for reusable use. Sizing of the pediatric Air-Q ILA is similar to the LMA in that it is weight-based: A size 1 is designed for patients <5 kg, size 1.5 for 5–10 kg, size 2 for 10–20 kg. In our case series, various cuffed TT sizes can be placed through the same size Air-Q ILA as seen with patients no. 1–3. (Table 1) all of our patients demonstrate that a smaller than weight-based size Air-Q ILA can be used without compromising ventilation parameters and allow for tracheal intubation with an appropriately sized cuffed TT. This would not have been possible with an equivalently sized classic LMA. The shaft of the classic LMA does not permit passage of a larger diameter TT or the pilot balloon of a cuffed TT (Table 1).

Patients no. 1 and no. 5 were intubated through both the classic LMA as well as the Air-Q ILA providing a comparison. The superior glottic views seen with the Air-Q ILA may be the result of features designed to lift the epiglottis and improve airway alignment (Figure 1). There are however some limitations to the Air-Q ILA. It may not improve the view when used in conjunction with a flexible fiberoptic scope in the presence of blood and secretions. Even in this situation, the alignment with the glottic anatomy may allow for increased success in the use of a ‘light guided’ or blind techniques for intubation. This device is of limited value in nasotracheal intubations and patients with no mouth opening. When intubating neonates, if a continuous ventilation technique is employed as described by Weiss (7) a standard bronchoscope adapter will add length to the shaft of the Air-Q ILA, necessitating the use of a stabilizing rod. Once the Air-Q ILA airway connector is removed, the bronchoscope

<table>
<thead>
<tr>
<th>Features</th>
<th>Classic LMA</th>
<th>Air-Q ILA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shaft</td>
<td>Straighter; can be as long as the TT</td>
<td>Shorter and curved; allows for greater control of the TT</td>
</tr>
<tr>
<td>Grill</td>
<td>Present; may need to be cut in the disposable versions</td>
<td>Absent</td>
</tr>
<tr>
<td>TT Sizes</td>
<td>Only a narrow range of TT sizes will fit through the LMA</td>
<td>Can accommodate a larger range of cuffed and uncuffed TT’s as compared with an equivalently sized LMA, both based on body weight recommendations</td>
</tr>
<tr>
<td>Passage of TT pilot balloon</td>
<td>‘Hang up’ within shaft upon withdrawal of LMA</td>
<td>Removable adapter allows easy passage upon removal of air-Q ILA</td>
</tr>
<tr>
<td>Withdrawal of device when cuffed TT’s are used</td>
<td>More difficult; may require extra equipment (forceps, 2nd TT) or modification of LMA</td>
<td>Easy; a stabilizing rod is also available</td>
</tr>
</tbody>
</table>

TT, tracheal tube.

Table 2
A practical comparison of the classic laryngeal mask airway (LMA) to the Air-Q intubating laryngeal airway (ILA) as a conduit for tracheal intubation in children
adapter will no longer be able to be connected to the shaft.

We believe the use of the air-Q ILA may be a well-suited alternative to the classic LMA in children with difficult airways, especially when a cuffed TT is desired. In these patients with restricted mouth opening, this airway offers many advantages over the traditional LMA-assisted intubation. Future randomized controlled trials comparing the air-Q ILA to the classic LMA need to be carried out with particular attention to: (i) patient safety, (ii) ease of use, and (iii) time to intubation. This device may prove to be a valuable tool in the management of a difficult pediatric airway.

Disclaimer

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References


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Difficult pediatric airway management using the intubating laryngeal airway

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ABSTRACT

Objective: To evaluate the intubating laryngeal airway (ILA) in providing safe endotracheal intubation in pediatric patients with difficult airway; to describe a method for using flexible fiberoptic bronchoscopy with the ILA for evaluating the pediatric airway.

Methods: Case series with chart review of the medical records of patients who had the ILA and fiberoptic intubation used to secure the airway at a tertiary pediatric hospital from January 2009 to January 2011. We documented the circumstances necessitating airway management, ILA success, airway evaluation findings, and medical conditions contributing to difficult airway.

Results: Fifty patients met criteria for review. The median age was 59.8 months (0.3–244.1), and the median weight was 19.0 kg (2.6–86). Four cases (8%) were unanticipated difficult airways and 46 (92%) were anticipated difficult airways. Nine (18%) of the 50 procedures were performed emergently. Comorbid conditions included craniofacial syndromes (n = 36), cervical spine instability/immobility (n = 9), and airway hemorrhage (n = 3). 48 (96%) patients were fiberoptically intubated on first attempt through the ILA. In 2 patients, fiberoptic intubation required a second attempt. The overall success rate using the ILA and fiberoptic intubation to secure the airway was 100%.

Conclusion: ILA and fiberoptic-guided tracheal intubation is a safe and effective method for securing the airway in pediatric patients with difficult airway and can be a useful alternative to direct laryngoscopy when laryngeal exposure is suboptimal.

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1. Introduction

Otolaryngologists evaluate the pediatric airway to investigate a wide variety of medical conditions. Evaluation involves detailed examination of the anatomy, physiology, and pathology of the airway. An otolaryngologist’s assistance is also frequently requested to secure a difficult airway. Securing an airway involves providing a conduit for adequate ventilation and oxygenation, such as placing an endotracheal tube. A difficult airway can be defined as inability to provide facemask ventilation and/or inability to adequately expose the larynx with direct laryngoscopy (DL) [1]. This is often the situation in children with craniofacial disorders such as micrognathia among others.

For the otolaryngologist, direct laryngoscopy and rigid bronchoscopy (DLB) has long been the method of choice for evaluation of the pediatric airway. Rigid bronchoscopy can also be used to secure the airway as it allows ventilation through the bronchoscope [2]. However, in patients with limited laryngeal exposure by DL, rigid bronchoscopy can at times be difficult or impossible.

The standard laryngeal mask airway (LMA) is a supraglottic airway device that has long been used to secure routine and difficult airways. The ability to provide adequate ventilation with the LMA has been well established [3]. The LMA has also been used to assist in tracheal intubation in pediatric patients [4]. The LMA serves as a temporary ventilation tool and then as a conduit for fiberoptic intubation [5]. The ILA is a modified LMA designed more specifically for intubation through the device. A variety of ILA devices are available and have been used for some time. At our institution we have chosen to use the air-Q (Cookgals LLC, St. Louis, MO). The details of the design of the device are previously described by Jagannathan et al. [6].

At Lurie Children’s Hospital of Chicago we have been using the ILA since 2008 to aid in securing and evaluating difficult pediatric airways [7]. Advantages of the ILA over traditional LMAs include...
better epiglottic and glottic isolation, the ability to apply positive-pressure ventilation, and the ability to more reliably place a cuffed endotracheal tube through the device while minimizing the disconnect time from oxygen and anesthetic gases [8]. The purpose of this current study is not to compare ILA to traditional LMA, but rather to report our results using the ILA, specifically the success of the ILA in securing the airway in children with difficult airways. We did not seek to compare the air-Q to other LMA/ILA devices. We instead focused on demonstrating the ability of the ILA to facilitate anesthesia in pediatric patients with a difficult airway. Using a traditional LMA is also a reasonable option for difficult airway management. We present a modified airway-management algorithm originally adapted from the American Society of Anesthesiologists (ASA) algorithm for securing the difficult airway. We propose incorporation of the ILA into routine management for securing and evaluating the difficult pediatric airway.

2. Materials and methods

The Lurie Children’s Hospital of Chicago Institutional Review Board approved this study. The medical records of patients in whom the ILA was used to secure the airway from January 2009 to January 2011 were reviewed. The method of placing the ILA and its use as a conduit for fiberoptic endotracheal intubation is previously described [6]. In this study, intubation through ILA was performed by sliding a loaded endotracheal tube over a flexible fiberoptic bronchoscope or optical stylet.

Data gathered from the charts included: age, gender, weight, relevant airway anatomy; Cormack and Lehane grade [9]; ILA size; method of fiberoptic intubation; grade of endoscopic view (Table 1) [10]; size of endotracheal tube; number of attempts before successful intubation; the location of airway management; and any complications including laryngospasm, bronchospasm, regulation of gastric contents, aspiration or oxygen desaturation. Charts were also reviewed for the circumstances necessitating airway management, airway evaluation findings, and medical conditions contributing to the difficult airway.

Data were recorded and analyzed in Microsoft Excel. Categorical patient data and measurements were tallied. The rate of success, as defined by endotracheal intubation via ILA, was calculated by dividing the number of patients with successful endotracheal intubation by the number of patients with attempted intubation.

We reviewed the current difficulty airway management protocol published by the ASA. We present algorithms of our current airway management for securing and evaluating the difficult pediatric airway. Flow charts of these algorithms were constructed in Microsoft Visio.

3. Results

Fifty patients had the ILA placed with subsequent fiberoptic tracheal intubation to secure the airway. In all 50 patients tracheal intubation was successful. The median age was 59.8 months (range 0.3–244.1), and the median weight was 19.0 kg (range 2.6–86). Forty-six (92%) cases were anticipated difficult airways, while 4 (8%) cases were unanticipated difficult airways. The causes of the unanticipated difficult airways are listed in Table 2.

Selection of ILA size was based on the manufacturer’s recommendation and clinical judgment of the attending otolaryngologist and anesthesiologist. The ILA was placed successfully on the first attempt in 48 (96%) of 50 patients. One patient required downsizing of the ILA from a 2.5 to 2.0 for better seating. Another patient required downsizing of the ILA from a 2.5 to 2.0 as the 2.5 would not fit through the mouth. Successful placement of the ILA was defined as achieving adequate lung ventilation and demonstration of an appropriate capnography waveform. A summary of the sizes of ILA used can be seen in Table 2.

Forty-one (82%) of the 50 patients were intubated through the ILA by flexible fiberoptic bronchoscopy (FFB). The grade of view obtained during FFB guided intubation is seen in Table 2. Seven (14%) patients were intubated with a Shikani Optical Stylet (Clarus Medical, Minneapolis, MN, USA). Grades of fiberoptic view during Shikani Optical Stylet intubation are displayed in Table 2. Two (4%) patients underwent emergent, blind intubation through the ILA. One of these blind intubations required a second attempt. Nine (18%) patients required emergent airway management. The indications for emergent intubations are listed in Table 2. The hospital locations where intubation occurred are recorded in Table 2. Cuffed endotracheal tubes were used in 39 (78%) of the intubations. Two patients underwent blind intubation through ILA.

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Table 1

<table>
<thead>
<tr>
<th>Endoscopic grade of larynx [10]</th>
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<tbody>
<tr>
<td>Grade 1 view</td>
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<tr>
<td>Grade 2 view</td>
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<tr>
<td>Grade 3 view</td>
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<tr>
<td>Grade 4 view</td>
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<tr>
<td>Grade 5 view</td>
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</table>

Table 2

<table>
<thead>
<tr>
<th>Patient data.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reason for unanticipated difficult airway</td>
</tr>
<tr>
<td>Lingual tonsillar hypertrophy</td>
</tr>
<tr>
<td>Extreme anterior airway</td>
</tr>
<tr>
<td>(4)</td>
</tr>
<tr>
<td>Air-Q size</td>
</tr>
<tr>
<td>Size 1.0</td>
</tr>
<tr>
<td>Size 1.5</td>
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<td>Size 2.0</td>
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<td>Size 3.5</td>
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<td>(50)</td>
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<td>Grade of fiberoptic view with FFB [10]</td>
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<td>Grade 5 view</td>
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<tr>
<td>(41)</td>
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<tr>
<td>Grade of view with Shikani stylet [10]</td>
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<td>Grade 1 view</td>
</tr>
<tr>
<td>Grade 2 view</td>
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<td>Grade 3 view</td>
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<td>Grade 4 view</td>
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<td>(7)</td>
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<tr>
<td>Indications for emergent intubation</td>
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<tr>
<td>Acute respiratory distress</td>
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<tr>
<td>Airway hemorrhage</td>
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<tr>
<td>Acute pulmonary edema</td>
</tr>
<tr>
<td>(9)</td>
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<tr>
<td>Location of procedure</td>
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<tr>
<td>Operating room</td>
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<tr>
<td>Radiology suites</td>
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<tr>
<td>Intensive care unit</td>
</tr>
<tr>
<td>Emergency room</td>
</tr>
<tr>
<td>(50)</td>
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<tr>
<td>Cormak and Lehane grade of glottic view with DL</td>
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<tr>
<td>Grade 1 view</td>
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<tr>
<td>Grade 2 view</td>
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<td>Grade 3 view</td>
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<td>Grade 4 view</td>
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<td>(14)</td>
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<tr>
<td>Comorbid conditions</td>
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<tr>
<td>Craniofacial syndromes</td>
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<tr>
<td>Cervical spine instability/immobility</td>
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<tr>
<td>Airway hemorrhage</td>
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Of the 50 patients, 48 (96%) were intubated on the first attempt through the ILA. Two patients required a second intubation attempt. One patient required 2 attempts at fiberoptic intubation. The overall success rate was 100% for ILA-guided tracheal intubation in all patients \( n = 50 \). In 14 (28%) of the cases, a failed attempt to intubate by DL preceded the use of the ILA. In all 14 (100%) failed DL cases the ILA was subsequently used to successfully secure the airway. The Cormak and Lehane grades of the glottic view obtained by DL are displayed in Table 2. Comorbid conditions present in patients are listed in Table 2. Two patients with craniofacial syndrome also had mucopolysaccharidosis and were difficult to mask ventilate. One patient with mucopolysaccharidosis also had cervical stenosis. Oxygen desaturation to <85% was noted in 6 cases. One death was documented in a critically ill child despite successful tracheal intubation. The death was not related to airway obstruction but rather to other pathology. No reports of laryngospasm or bronchospasm were noted.

Fig. 1 displays the management algorithm proposed to aid in securing a difficult airway. Fig. 2 displays the management algorithm proposed to aid in evaluating difficult airway.

4. Discussion

The ILA was successful in facilitating endotracheal intubation in all 50 cases reviewed. A majority of the difficult airways were anticipated after preoperative assessment, or from a documented history of inability to provide facemask ventilation and/or the inability to adequately expose the larynx with DL. However, in 4 cases the difficult airway was unanticipated. An anterior larynx limiting exposure by DL was the most common cause of a difficult airway. While a majority of our patients were intubated through the ILA by FFB, 7 (14%) patients were intubated with the Shikani optical stylet. The stylet was used earlier in the study as we were developing a preferred technique. We now prefer FFB for intubation as this can also provide lower airway visualization in the same procedure. The ILA proved successful in emergency situations and in a variety of locations. Blind intubation in 2 cases was likely successful due to isolation of the larynx by the ILA. The correct size of ILA was selected in 48 (96%) of 50 patients, indicating a good predictability of size requirement. In the 2 patients in whom size was incorrect initially, the next size down seated appropriately.

Endoscopic grading of the airway [10] revealed that with the ILA a majority [37/41, 90.2%] of difficult airways achieved a grade 1 or 2 endoscopic view. Poor endoscopic view usually was due to epiglottic down folding. Endotracheal tube placement over FFB was possible on the first attempt in all but 1 of the cases. Following manipulation of the ILA position, success was achieved on second attempt. Fourteen cases had an unsuccessful DL performed prior to ILA placement. These patients all had a Cormak and Lehane grade 3 or 4 view. Ultimately, the ILA was able to facilitate intubation in these patients. There was an improvement in the glottic view with ILA and FFB when compared to DL in these patients. The superior view is likely due to the ILA isolating the epiglottis; however, at times the epiglottis can be down folded by the ILA and thus prevent complete visualization.

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Cranial–facial syndromes such as Pierre Robin, Goldenhar, and Treacher Collins accounted for the majority of predicted difficult airways. The common feature of these syndromes is micrognathia, a condition that limits the ability to keep the larynx out of the airway. If the ILA combined with FFB allows endotracheal intubation without the need for cervical spine extension, which is optimal in patients with cervical immobility or instability. Oxygen desaturation was recorded in only 6 cases. In 5 of these cases, the episodes were brief and promptly reversed with positive-pressure ventilation through the ILA, demonstrating the ability of the air-Q to ventilate the patient while preparing for and performing fiberoptic intubation. In the 1 patient who died, poor oxygenation was a result of massive pulmonary edema and was not reversed even with mechanical ventilation with an endotracheal tube. There was no report of increased bronchospasm or laryngospasm with the ILA and fiberoptic intubation.

Given the high success rate of the ILA in facilitating endotracheal intubation, we believe it to be a safe and valuable tool in both securing and evaluating the difficult pediatric airway. The use of the ILA allows intubation via endoscopic visualization, provides hands-free airway/ventilation, and minimizes the disconnect time from oxygen. This is critically important in neonates and infants with poor respiratory reserve [11]. For these reasons the ILA has many advantages over other modalities of approaching the airway. We have adapted our airway management accordingly given the positive results when using the ILA.

We currently use the following 2 algorithms for both securing and evaluating the difficult pediatric airway (Figs. 1 and 2). At times an otolaryngologist may be able to place a rigid bronchoscope in the setting of poor visualization on DL. If successful, an exchange catheter may be used to place an endotracheal tube into the airway. We have encountered patients where placement of rigid bronchoscopy is not possible or at least met with much resistance. The ILA combined with FFB provides a safe method to secure the airway with endotracheal intubation in these patients. We believe FFB intubation through the ILA is less traumatic and is our first choice for securing the airway in these patients.

Fig. 1 demonstrates our method of securing the difficult pediatric airway. The goal is to provide stable and safe endotracheal ventilation. While mask or laryngeal mask ventilation may be adequate for some situations, an endotracheal tube is often required for prolonged procedures. If the airway is known or suspected to be difficult, we strongly consider proceeding directly to placement of the ILA. It is reasonable in some situations to consider DL rather than ILA, but extra care should be taken, especially in children with micrognathia. Once ventilation with the ILA is confirmed, anesthetic may be given to the patient to facilitate FFB. FFB is then used to fiberoptically intubate the patient through the ILA.

The flexible fiberoptic bronchoscope, when used to intubate through the ILA, provides clear visualization of the airway and allows confirmation of endotracheal tube placement with location relative to the carina. The ILA may then stay in its position or be removed as previously described [13].

Our algorithm for airway evaluation is presented in Fig. 2. During airway evaluation the goal is to visualize the key structures of the upper and lower airway in search of pathology while providing safe anesthetic ventilation. First, flexible fiberoptic laryngoscopy (FFL) is performed in an awake, unsedated patient. Awake laryngoscopy is useful to evaluate dynamic function of the larynx, including vocal fold movement. After FFL, anesthesia will then attempt mask ventilation. If there is difficulty with mask ventilation, the airway is considered a difficult airway. We may proceed directly to ILA placement or still attempt DL. If DL is unsuccessful, this serves as further confirmation of a difficult airway. We then would proceed to ILA placement to provide adequate ventilation. If DL is successful, we size the subglottis using the Cotton/Myer method [12] and proceed with DLB for lower airway evaluation. The rigid bronchoscope may also be used for ventilation. If further procedures requiring a secure airway are to be performed, an endotracheal tube may be placed by DL.

If the patient is suspected or known to have a difficult airway and evaluation is indicated, we strongly consider proceeding directly to ILA placement after awake FFL evaluation. It is reasonable to still attempt DL in some situations and proceed to ILA placement only if DL is unsuccessful. However, in patients with a known difficult airway, extra caution should be taken with DL as this often requires sedation that can lead to airway obstruction, particularly in patients with micrognathia. A well placed ILA will allow ventilation while preparing for FFB to evaluate the lower airway. FFB can then be used to intubate through the ILA if further procedures requiring a secure airway are planned. We have found that when combined with FFL, FFB through ILA provides visualization of the entire airway.

Having an ILA readily available when securing and/or evaluating the pediatric airway, particularly the difficult airway, is now routine in our institution. We feel this device, combined with FFB, significantly increases our ability to safely care for these children. While useful in many situations, the ILA is particularly useful in children with craniofacial anomalies such as micrognathia. These patients often have limited laryngeal exposure by traditional DL.

Our study has limitation in that it is retrospective in nature. There was also no initial evaluation with DL if the airway was predicted to be difficult. Although the ILA was easy to place in most patients with a difficult airway, the device does require a certain size of mouth opening. Our primary goal was to help to establish the ILA as a device to aid in difficulty intubations and to share our management algorithm with institutions that have not yet tried the ILA.

In conclusion, ILA and fiberoptic guided tracheal intubation is a safe and effective method for securing the airway in pediatric patients with a difficult airway and can be a useful alternative to DL when laryngeal exposure is suboptimal.

References

Case Report

Use of the air-Q® intubating laryngeal airway for rapid-sequence intubation in infants with severe airway obstruction: a case series*

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1 Attending Pediatric Anesthesiologist and Assistant Professor, 2 Fellow in Pediatric Anesthesia, Ann & Robert H. Lurie Children’s Hospital of Chicago, Department of Pediatric Anesthesia, Northwestern University Feinberg School of Medicine, Chicago, IL, USA

Summary
We describe a four-step method for fibreoptic-guided, rapid-sequence tracheal intubation through the air-Q® intubating laryngeal airway in infants with severe airway obstruction. Our step-wise process provides an organised and controlled approach to safely securing the airway.

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*Presented in part at the Society for Pediatric Anesthesia Annual Meeting, Las Vegas, NV, USA, March 2013.
Accepted: 22 February 2013

Recently published difficult airway guidelines recommend the use of a supraglottic airway device (SAD) in children with difficult airways [1]. The air-Q® intubating laryngeal airway (Cookgas LLC, Mercury Medical, Clearwater, FL, USA) is a SAD that has been shown to be an effective conduit for tracheal intubation either blindly [2] or with fibreoptic assistance [3, 4]. We describe a four-step method for tracheal intubation through the air-Q in three infants with a predicted difficult airway and severe airway obstruction in whom the awake placement of an air-Q was used to facilitate rapid-sequence tracheal intubation.

Case reports
All three cases involved infants at risk of aspiration, with Pierre Robin Syndrome (micrognathia, glossoptosis and cleft palate) and severe upper airway obstruction as evidenced by tachypnoea and sternal recession requiring supplementary oxygen. Infant one was a 4.1-kg, 6-week-old girl with CHARGE syndrome (coloboma, heart defects, choanal atresia, growth retardation, genitourinary problems and ear abnormalities), vocal cord paralysis and dysphagia who required gastrostomy tube insertion, tracheostomy, nasal endoscopy and bilateral myringotomy. Infant two was a 4.0-kg, 3-week-old boy with dysphagia and gastrointestinal reflux presenting for tracheostomy. Infant three was a 3.6-kg, 8-week-old boy with small bowel obstruction presenting for exploratory laparotomy followed by tracheostomy. Pre-operatively, baseline oxygen saturation on room air had been recorded as between 85% and 95% in all three infants.

The anaesthetic technique was the same in all three cases (Fig. 1). Intravenous access was established before the start of the case and the stomach decompressed with a nasogastric tube that was then removed. First, in the awake infant, the airway was topicalised with 2% lidocaine gel, either by swabbing the posterior pharynx with the clinician’s gloved finger; or delivered via a pacifier with several perforations that was placed in the patients’ mouth [5]. Second, a size −0.5 or −1 air-Q was inserted according to the manufacturer’s
instructions using a standard midline technique with the red plastic tag attached to the pilot balloon. The cuff of the air-Q was then inflated until minimal airway leak was detected. Acceptable airway positioning was verified by observing a tidal volume of at least 6 ml.kg\(^{-1}\) whilst making minor adjustments to the position of the device to maintain adequate ventilation. Awake placement of the air-Q was well tolerated by all three infants with minimal coughing, breath-holding or gagging, and resulted in relief of upper airway obstruction with immediate improvement in oxygenation.

Third, after removal of the 15-mm proximal air-Q connector, a fiberoptic bronchoscope preloaded with an appropriately sized, lubricated, cuffed tracheal tube, was placed through the air-Q to verify the laryngeal alignment and adjusted, if necessary, to optimise the glottic view. Fourth, after confirming adequate anatomical and functional position of the air-Q and pre-oxygenation, an induction agent (propofol or ketamine) and suxamethonium 1 mg.kg\(^{-1}\) was administered intravenously to facilitate tracheal intubation whilst viewing the larynx with the fiberoptic bronchoscope. Once the trachea was intubated and correct placement confirmed by capnography, the air-Q was removed using a removal stylet to stabilise the tracheal tube. With improvement in airway patency, oxygen desaturation did not occur in any patient during fiberoptic bronchoscopy or whilst the breathing circuit was temporarily disconnected. Tracheal intubation, with an appropriately sized cuffed tracheal tube, and removal of the air-Q were both successful on the first attempt in all three patients.

**Discussion**

It is preferable to have an awake patient during difficult airway scenarios, but in a vigorous infant with severe airway obstruction and hypoxaemia, intubating conditions are often suboptimal. The insertion of SADs to facilitate fiberoptic-guided tracheal intubation in awake children has been described previously [6].

*Figure 1* Panels (a–d). A four-step method for fiberoptic-guided, rapid-sequence tracheal intubation through the air-Q intubating laryngeal airway. (a) Upper airway topicalisation by swabbing the posterior pharynx with the clinician’s gloved finger with 2% lidocaine gel (shown); or delivered via pacifier with perforations placed in the patient’s mouth. (b) Insertion of air-Q using a standard midline technique with red plastic tag attached to the pilot balloon (size –1 air-Q shown). (c) Verification of acceptable SAD position. Minor adjustments may be made to optimise ventilation. (d) View of anatomical position with fiberoptic bronchoscope (note the 15-mm adaptor of the air-Q must be removed before fiberoptic intubation). Once anatomical alignment is acceptable, an induction agent and neuromuscular blocking drug is administered.
Advantages of an awake placement of an SAD include preserved protective airway reflexes, with improvement in ventilation and oxygenation by relieving upper airway obstruction, whilst still maintaining spontaneous respiration. In adults, it has been demonstrated that airway topicalisation and placement of an SAD does not affect the resting gastro-oesophageal barrier pressure or upper oesophageal sphincter pressure [7]. Given these findings, one can infer that the placement of an SAD itself should not increase the risk of aspiration in an awake patient. Caring for infants with a predicted difficult airway and at risk of gastric aspiration can be challenging; our method provides a practical approach in making rapid-sequence tracheal intubation a viable option in these situations by incorporating the awake SAD technique.

Once upper airway obstruction has been relieved and the feasibility of a fibreoptic-guided intubation through the SAD confirmed, the clinician may elect to proceed with awake tracheal intubation without the use of neuromuscular blockade. However, in practice, we believe that administration of an anaesthetic induction agent and neuromuscular blockade before the intubation process minimises the risk of trauma, laryngospasm, bronchospasm and potential dislodgement of the tracheal tube. If the child is not at risk of aspiration, anaesthesia may be induced with sevoflurane inhalation via the SAD, and the airway maintained using the SAD alone, or the trachea may be intubated under deep inhalational anaesthesia with or without the use of neuromuscular blockade. The limitations to this method for rapid-sequence tracheal intubation include dislocation of the SAD in a vigorous infant, gagging and regurgitation, and the delay between administration and onset of action of suxamethonium, during which time the infant may be at risk of aspiration.

In conclusion, we describe a novel method to overcome upper airway obstruction in infants with a predicted difficult airway, providing a practical option for rapid-sequence tracheal intubation. Approaching the difficult infant airway in this controlled, step-wise manner reduces the likelihood of airway obstruction and its associated complications.

Acknowledgement
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Competing interests
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Competing interests
No external funding and no competing interests declared.

References
A randomised comparison of the self-pressurised air-Q™ intubating laryngeal airway with the LMA Unique™ in children

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Summary
We conducted a randomised trial comparing the self-pressurised air-Q™ intubating laryngeal airway (air-Q SP) with the LMA-Unique in 60 children undergoing surgery. Outcomes measured were airway leak pressure, ease and time for insertion, fibreoptic examination, incidence of gastric insufflation and complications. Median (IQR [range]) time to successful device placement was faster with the air-Q SP (12 (10–15 [5–18]) s) than with the LMA-Unique (14 (12–17 [6–22]) s; p = 0.05). There were no statistically significant differences between the air-Q SP and LMA-Unique in initial airway leak pressures (16 (14–18 [10–29]) compared with 18 (15–20 [10–30]) cmH2O, p = 0.12), an airway leak pressures at 10 min (19 (16–22 [12–30]) compared with 20 (16–22 [10–30]) cmH2O, p = 0.81); fibreoptic position, incidence of gastric insufflation, or complications. Both devices provided effective ventilation without the need for airway manipulation. The air-Q SP is an alternative to the LMA-Unique should the clinician prefer a device not requiring cuff monitoring during anaesthesia.

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Several new supraglottic airway devices are available for use in paediatric patients. The laryngeal mask airway (LMA) Unique™ (LMA North America, San Diego, CA) is a single-use supraglottic airway device with an established efficacy in both adults and children [1, 2]. The self-pressurised air-Q™ intubating laryngeal airway (air-Q SP; Cookgas LLC, Mercury Medical, Clearwater, FL) is a new single-use device that may optimise the airway seal while reducing the potential for postoperative pharyngo-laryngeal morbidity. The overall structure of the air-Q SP is identical to the original air-Q, except with regard to the inflatable cuff. Instead, there is an inner aperture at the junction of the airway tube and the mask cuff, creating an open airspace between the two, and allowing the pressure to be self-regulated (Fig. 1). This feature of the air-Q SP may provide for easier device insertion, reduced risk for prolonged overinflation of the cuff and pressure-related injuries to the pharyngeal mucosa without the need for cuff pressure monitoring.

Studies have shown the original air-Q to be an effective device for airway maintenance [3, 4], and as a
conduit for tracheal intubation in both adults [5] and children [6]. To date, only one observational study has been reported using the air-Q SP in children [7], and there are no randomised studies using this device in either adults or children. The aim of this randomised trial was to evaluate the clinical performance of the air-Q SP compared with the LMA Unique. Ease and time for insertion, insertion success rate, airway leak pressures, incidence of gastric insufflation, fibreoptic laryngeal view, quality of airway during anaesthetic maintenance and complications were assessed.

Methods
This study was approved by the Children’s Memorial Hospital Research Center’s Institutional Review Board and written informed consent was obtained from the parents of all patients. Children weighing 20–30 kg, 3–9 years of age, of ASA physical status 1–3, scheduled for elective outpatient surgery in which airway management with a LMA would be appropriate, were enrolled in this study. Patients were excluded if they had active respiratory illness (cough, fever, rhinorrhea) on the day of anaesthesia, inability to report (e.g. due to developmental delay) postoperative complaints such as sore throat, or a potentially difficult airway. Patients were screened and recruited consecutively based on eligibility criteria, and availability of the study investigators.

Sixty children were randomly allocated by a computer-generated list using Microsoft Excel (Redmond, WA, USA) to receive either a size-2 air-Q SP or 2.5 LMA Unique. The study investigator was only made aware of the allocation immediately before device insertion. The standardised anaesthetic protocol consisted of an inhalational induction with 8% sevoflurane in 70% nitrous oxide and oxygen followed by intravenous access, and administration of fentanyl 1 μg·kg⁻¹. Manual ventilation of the lungs was continued until the heart rate was at least 20% lower than pre-fentanyl values with an end-tidal sevoflurane concentration of 2.5% maintained before device insertion. Adequate anaesthetic depth was confirmed by the lack of a motor response to jaw thrust [8]. A supplementary dose of 1 μg·kg⁻¹ fentanyl was allowed if the depth of anaesthesia was considered insufficient for device placement. Each device was lubricated with a water-based agent before placement.

A standard midline insertion technique was used for both devices, according to the manufacturer’s recommendations. All patients were maintained with at least 2% sevoflurane in 60% nitrous oxide and oxygen. No neuromuscular blocking drugs were administered. Three study investigators experienced with the use of both devices (over 500 insertions with the LMA Unique and at least 50 insertions with the air-Q SP) performed all the insertions. One investigator managed the airway, inserted the device and obtained the fibreoptic views for grading, while a second investigator recorded the airway leak pressures and assessed for gastric insufflation. An unblinded observer assisted with the measurement of

Figure 1 The self-pressurised air-Q intubating laryngeal airway (air-Q SP) size 2. (a) Frontal view. The air-Q SP lacks an inflatable cuff for its mask bowl. (b) View of the air-Q SP mask bowl. Note the inner aperture (arrow) at the junction of the airway tube and the mask cuff, creating an open airspace between the two that allows the intracuff pressure to be self-regulated. The proximal portion of the mask bowl has been cut to reveal its inner orifice.
time, recorded the fibreoptic views and ensured collection of all data.

The time for successful insertion was measured from the moment the facemask was removed until the first capnography upstroke after insertion. For patients receiving the LMA Unique, the intracuff pressure was standardised to 60 cmH2O using an aneroid cuff pressure gauge (Ambu Inc., Glen Burnie, MD, USA). The ease of placement was assessed using a subjective scale of 1–4 (1 = no resistance, 2 = mild resistance, 3 = moderate resistance, 4 = inability to place the device). Insertion was recorded as a failure if the device could not be successfully placed within two attempts, lacked a square-wave capnograph tracing, resulted in airway obstruction (diagnosed by oxygen desaturation < 90%, abnormal thoraco-abdominal movements, or obstructive noises), or there was inadequate ventilation (an inability to generate 7–10 ml.kg⁻¹ tidal volumes). The patient’s trachea was to be intubated should there be a failed insertion.

To determine the leak pressure, the expiratory valve was closed with a fresh gas flow of 3 Lmin⁻¹ until equilibrium was reached [9] (not allowed to exceed 40 cmH2O), and then released completely. Auscultation with a stethoscope was performed over the epigastrium during leak pressure testing to detect the occurrence of gastric insufflation [10]. A flexible fibreoptic scope (LF-V, 4.1 mm; Olympus America Inc., Melville, NY, USA) was used to view the anatomic alignment of the device to the larynx, 1 cm proximal to the airway orifice. The images were graded as follows [11]: Grade 1, larynx only seen; Grade 2, larynx and epiglottis posterior surface seen; Grade 3, larynx and epiglottis tip of anterior surface seen, less than 50% visual obstruction of epiglottis to larynx; Grade 4, epiglottis downfolded and its anterior surface seen, greater than 50% visual obstruction of epiglottis to larynx; Grade 5, epiglottis downfolded and larynx cannot be seen directly. A second airway leak pressure and a second fibreoptic view were both taken 10 min after the initial leak pressure and initial fibreoptic view to observe if there was a change in the airway seal.

The mode of ventilation for maintenance of anaesthesia (spontaneous, pressure support, or mechanical) was at the discretion of the anaesthetist, and recorded. Ventilation was adjusted to maintain the end-tidal carbon dioxide between 4.0 and 4.5 kPa during anaesthetic maintenance. The quality of the airway (clear, intermittent partial obstruction, intermittent complete obstruction, or complete obstruction) [12], and the number and type of airway manipulations (gentle advancement, withdrawal of device without removal, jaw thrust, or neck extension) required to maintain airway patency during the case were also recorded. Failure of the device during maintenance of anaesthesia was defined as inadequate ventilation (using the same criteria as above for device insertion, and/or end-tidal carbon dioxide > 5.9 kPa), airway obstruction that could not be corrected with airway manipulation, or the need for replacement of device with a tracheal tube. At the conclusion of the procedure, the intracuff pressure was checked and recorded for those patients who had received the LMA Unique.

All devices were removed under a deep plane of anaesthesia at the conclusion of the procedure. Complications with each device, such as airway reflex activation (coughing, laryngospasm, or bronchospasm), desaturation (SpO2 < 90%), gastric insufflation and bloodstaining on the device after removal, were also noted. All patients were seen in the postanaesthetic recovery ward by a blinded investigator. They also received a follow-up phone call the next day from a registered nurse who was not part of the study, to document any postoperative complications, such as sore throat, dysphonia, dysphagia, cough, or stridor, as reported by the child and/or the parents.

The primary outcome variable was airway leak pressure, and it was anticipated that with the air-Q SP these would be no less than 25% than that of the LMA Unique. Previous data with the air-Q SP suggested that the initial leak pressure with the size 2 was 17 (5) cmH2O in this patient population. After 10 min, the leak pressure was found 19 (5) cmH2O. A leak pressure difference of 4 cm H2O (the minimum difference considered to be clinically significant) on initial leak pressure testing, and/or at 10 min after placement, would be required to detect a significant difference between these two devices. Using this effect size, an alpha of 0.05, and a desired power of 0.9, we estimated that 27 patients would be required per device to demonstrate this difference in leak pressure between these two devices. This study enrolled 60 patients (30 in
each group) to allow for the potential dropout of subjects.

Data were recorded intra-operatively using a standardised data collection sheet, and analysed using Microsoft Excel and the statistical software PASW Statistics 18 (SPSS Inc., Chicago, IL, USA). Statistical comparisons between devices were made using Student’s t-test for continuous data, chi-squared test for categorical data and Mann–Whitney U-test for ordinal data. A p value < 0.05 was considered statistically significant.

**Results**

Eighty patients were screened for enrolment in the study. After the study was explained and the patient information was read, twenty parents declined to participate. No patients were excluded for violation in protocol or refusal to participate after consent was given. Patients’ characteristics and surgical data are presented in Table 1 and comparative data between the air-Q SP and LMA Unique are seen in Table 2.

There were no statistically significant differences with regard to success rates of device insertion, airway leak pressures (initial and at 10 min), gastric insufflation, fibreoptic grade of view (initial and at 10 min), quality of airway achieved, number of airway manipulations, and complications between the air-Q SP and LMA Unique. All devices in both groups were successfully placed at the first attempt. All patients in both groups had a clear airway without the need for airway manipulation. There were no instances of device failure during maintenance of anaesthesia, or conversion to a tracheal tube.

There were statistically significant differences for time to successful placement and subjective ease of placement between the devices (Table 2). Blood on the device was only seen with one patient, who received the LMA Unique, which had also been moderately difficult to place. Follow-up phone calls revealed five patients with postoperative complaints, all from the LMA Unique group: one with dysphonia and four children with dysphagia; all five children complained of a sore throat, including the child with bloodstaining on the LMA Unique. Children with a sore throat had intracuff pressures of 58, 63, 64, 73, 78 cmH2O. There were no episodes of gastric regurgitation, aspiration, laryngospasm, bronchospasm, or stridor in any of the patients.

**Discussion**

Our results suggest that the air-Q SP was faster to insert than the LMA Unique in children, although the clinical effect was marginal. The devices demonstrated similar airway leak pressures and overall clinical performance. The overall insertion success rates were similar to those reported by other randomised trials with the air-Q, LMA Unique, and classic LMA in children [4, 13, 14]. The airway tube of the air-Q SP is more flexible than the LMA Unique and could affect the subjective ease of placement, but insertion times were still faster with the air-Q SP. This is likely to be due to the elimination of the cuff inflation step for device placement, a finding also seen with the use of the i-gel in children [15]. The insertion times for the LMA Unique in this study are consistent with another randomised trial in children [16].

The airway leak pressures of the air-Q SP in this study were also similar to those reported with both the size-2 air-Q with an inflatable cuff [4, 6] and the size-2 air-Q SP [7] in children, but lower than in adult patients [3, 17]. The LMA Unique airway leak pressures at

---

**Table 1** Patient and operative characteristics for the self-pressurised air-Q (air-Q SP) and LMA Unique. Values are median (IQR [range]) or number (proportion).

<table>
<thead>
<tr>
<th></th>
<th>air Q-SP (n = 30)</th>
<th>LMA Unique (n = 30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age; years</td>
<td>7.0 (4.8–8.6)</td>
<td>6.7 (5.9–7.9)</td>
</tr>
<tr>
<td></td>
<td>[4.1–9.4]</td>
<td>[4.3–9.8]</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>20 (67%)</td>
<td>18 (60%)</td>
</tr>
<tr>
<td>Female</td>
<td>10 (33%)</td>
<td>12 (40%)</td>
</tr>
<tr>
<td>Weight; kg</td>
<td>25.5 (23.0–30.0)</td>
<td>24.8 (22.2–26.8)</td>
</tr>
<tr>
<td></td>
<td>[20.1–30.5]</td>
<td>[20.0–30.8]</td>
</tr>
<tr>
<td>ASA physical status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>16 (53%)</td>
<td>21 (70%)</td>
</tr>
<tr>
<td>2</td>
<td>9 (30%)</td>
<td>5 (17%)</td>
</tr>
<tr>
<td>3</td>
<td>5 (17%)</td>
<td>4 (13%)</td>
</tr>
<tr>
<td>Duration of procedure; min</td>
<td>59 (43–78)</td>
<td>67 (45–85)</td>
</tr>
<tr>
<td></td>
<td>[20–178]</td>
<td>[17–214]</td>
</tr>
<tr>
<td>Type of procedure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urology</td>
<td>7 (23%)</td>
<td>4 (13%)</td>
</tr>
<tr>
<td>Imaging</td>
<td>3 (10%)</td>
<td>4 (13%)</td>
</tr>
<tr>
<td>General</td>
<td>9 (30%)</td>
<td>13 (44%)</td>
</tr>
<tr>
<td>Ophthalmology</td>
<td>5 (17%)</td>
<td>3 (10%)</td>
</tr>
<tr>
<td>Orthopaedic</td>
<td>6 (20%)</td>
<td>6 (20%)</td>
</tr>
</tbody>
</table>
10 min in this study were higher than with other randomised trials on the paediatric-sized classic LMA [14, 18, 19], and LMA Unique [13, 16]. An increase in airway leak pressure of both devices at 10 min may indicate some degree of moulding of the device in the posterior pharynx improving airway seal. Adjustments of the intracuff pressure are sometimes needed to maintain an adequate airway seal and prevent overinflation of the cuff when using supraglottic airways [20–22]. In this respect, the use of the air-Q SP may represent a benefit, as it may be more convenient than supraglottic airways with inflatable cuffs.

Fibreoptic examination through both the air-Q SP and the LMA Unique demonstrated similar anatomic alignment, and may not always correspond to the functional position of the device, as is often seen in children [23]. Even with some epiglottic downfolding present, both devices provided adequate ventilation parameters without evidence of airway obstruction, or

Table 2: Comparative data for the self-pressurised air-Q (air-Q SP) and LMA Unique. Values are median (IQR [range]), number, or number (proportion).

<table>
<thead>
<tr>
<th></th>
<th>air-Q SP (n = 30)</th>
<th>LMA Unique (n = 30)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to successful placement; s</td>
<td>12 (10–15 [5–18])</td>
<td>14 (12–17 [6–22])</td>
<td>0.05</td>
</tr>
<tr>
<td>Ease of device placement*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/2/3/4</td>
<td>24/6/0/0</td>
<td>29/0/1/0</td>
<td>0.02</td>
</tr>
<tr>
<td>Single attempt required</td>
<td>30 (100%)</td>
<td>30 (100%)</td>
<td>1.00</td>
</tr>
<tr>
<td>Leak pressure initial; cmH2O</td>
<td>16 (14–18 [10–29])</td>
<td>18 (15–20 [10–30])</td>
<td>0.12</td>
</tr>
<tr>
<td>Leak pressure at 10 min; cmH2O</td>
<td>19 (16–22 [12–30])</td>
<td>20 (16–22 [10–30])</td>
<td>0.81</td>
</tr>
<tr>
<td>Gastric insufflation</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>28 (93%)</td>
<td>27 (90%)</td>
<td>0.64</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>2 (7%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 (10%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fiberoptic grade† initial</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/2/3/4/5</td>
<td>10/12/3/3/2</td>
<td>4/15/5/4/2</td>
<td>0.47</td>
</tr>
<tr>
<td>Fiberoptic grade† at 10 min</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/2/3/4/5</td>
<td>10/8/7/3/2</td>
<td>5/13/6/4/2</td>
<td>0.55</td>
</tr>
<tr>
<td>Airway quality</td>
<td>Clear</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30 (100%)</td>
<td>30 (100%)</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Intermittent partial obstruction</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Intermittent complete obstruction</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Complete obstruction</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>No airway manipulation required</td>
<td>30 (100%)</td>
<td>30 (100%)</td>
<td>1.00</td>
</tr>
<tr>
<td>Intracuff pressure at end of case; cmH2O</td>
<td>-</td>
<td>62 (55–66 [28–78])</td>
<td>-</td>
</tr>
<tr>
<td>Type of ventilation</td>
<td>Controlled</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 (10%)</td>
<td>4 (13%)</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>Pressure support</td>
<td>25 (83%)</td>
<td>18 (60%)</td>
</tr>
<tr>
<td></td>
<td>Spontaneous</td>
<td>2 (7%)</td>
<td>8 (27%)</td>
</tr>
<tr>
<td>Intra-operative complications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>30 (100%)</td>
<td>29 (97%)</td>
</tr>
<tr>
<td></td>
<td>Airway related‡</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Blood on removal</td>
<td>0</td>
<td>1 (3%)</td>
</tr>
<tr>
<td>Postoperative complications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>30 (100%)</td>
<td>25 (83%)</td>
</tr>
<tr>
<td></td>
<td>Dysphonia (sore throat)</td>
<td>0</td>
<td>1 (3%)</td>
</tr>
<tr>
<td></td>
<td>Dysphagia (sore throat)</td>
<td>0</td>
<td>4 (14%)</td>
</tr>
<tr>
<td></td>
<td>Cough</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*Ease of device insertion as graded by the following subjective scale: 1 = no resistance; 2 = minimal resistance; 3 = moderate resistance; 4 = unable to place device.
†Grade 1, larynx only seen; Grade 2, larynx and epiglottis posterior surface seen; Grade 3, larynx and epiglottis tip of anterior surface seen, less than 50% visual obstruction of epiglottis to larynx; Grade 4, epiglottis downfolded and its anterior surface seen, greater than 50% visual obstruction of epiglottis to larynx; Grade 5, epiglottis downfolded and larynx cannot be seen directly. [11]
‡Includes laryngospasm, bronchospasm, stridor and coughing.
need for airway manipulations. This suggests an adequate airway stability of both devices during anaesthetic maintenance. Although it has been shown that the air-Q gives more favourable fiberoptic views compared with the LMA Unique in smaller children [4], this finding was not observed in the current study. The hypopharyngeal seal, as evidenced by comparable rates of gastric insufflation, was similar with both devices and also consistent with the frequency seen in other studies with the air-Q and LMA Unique in children [4, 16].

There were no differences in the overall complication rates between the two devices, despite the air-Q SP’s theoretical advantages. Of note, we did not find an overall increased frequency of sore throat in the children from the LMA Unique group with intracuff pressures greater than 60 cmH₂O at the end of the case. This increase in intracuff pressure may be attributed to the use of nitrous oxide, especially with longer anaesthetic duration, or changes in the LMA Unique position within the posterior pharynx, highlighting the importance of interval monitoring of intracuff pressures [22].

There are several limitations to this study. First, we only studied healthy children, and our results may not apply to children with poor lung compliance. Second, only one device size was studied. Third, data were collected by unblinded observers, which may have introduced bias. Fourth, our results may not apply to children receiving neuromuscular blockade. Finally, the mucosal pressure exerted on the posterior pharynx by the air-Q SP was not directly measured, and this could be a subject for future study, as has been done with the i-gel in adult patients [24].

Acknowledgements
The authors thank the anaesthesia attending staff at Children’s Memorial Hospital for allowing us to switch assignments and recruit patients and Grace Lee (Johns Hopkins Bloomberg School of Public Health) for statistical assistance. The air-Q SP was provided by Cookgas LLC and we thank Dr. Daniel J. Cook for this help, but no commercial financial support was granted either to our institution or to any of the listed authors.

Competing interests
No external funding or competing interests declared.

References


Title: The air-Q™ Intubating Laryngeal Airway as a means of rescue ventilation and blind tracheal intubation in two pediatric patients with airway bleeding

Author(s): JR Stockman and N Jagannathan

Affiliation(s): Northwestern University Children’s Memorial Hospital, Chicago, IL

Introduction: The ‘can’t ventilate, can’t intubate’ scenario is a very rare event in pediatric patients. However, the incidence is not zero, as a study of the National Emergency Airway Registry Database found that 0.56% of intubations required cricothyrotomy (1). Means of circumventing the surgical route and preserving ventilation by use of the laryngeal mask airway is an accepted part of the difficult airway algorithm (2). Furthermore, the intubating LMA (ILMA), LMA-Fastrach™, and LMA-CTrach™ (LMA North America: San Diego, CA, USA) are accepted supraglottic airway devices for the difficult airway in the adult population (3). However, the presence of such devices has not been available for use in the pediatric emergent airway. The air-Q™ intubating laryngeal airway (air-Q ILA) (Cookgas LLC: St. Louis, MO, USA) is a new supraglottic airway device available for the pediatric population. The air-Q ILA shares an insertion technique similar to the LMA-Classic™ (cLMA). It provides a conduit for tracheal intubation using a cuffed endotracheal tube, which is similar to the ILMA (4). The air-Q ILA is available in sizes appropriate to accommodate the pediatric airway. Thus, it has potential for use as a rescue airway device in the pediatric patient following a failed tracheal intubation. We present two pediatric bleeding airway cases requiring blind tracheal intubation through the air-Q ILA following failed rapid sequence with direct laryngoscopy in the emergency department.

Case 1: A 5-yr-old, 28 kg male presented to the emergency department for bleeding one day after tonsillectomy. He had a history of obstructive sleep apnea. A rapid sequence intubation was performed and made difficult by extensive bleeding in the oropharynx. The glottic opening could not be intubated after two attempts. A size 2 air-Q ILA was inserted, and a cuffed 5.0 mm ID endotracheal tube (ETT) was blindly inserted through the lumen. Placement was confirmed with end-tidal capnography.

Case 2: A 13-yr-old, 40 kg male presented to the emergency department following a motor vehicle accident. He was previously healthy, but presented with a large nasopharyngeal laceration. He was disoriented, but hemodynamically stable. A decision was made to undergo rapid sequence intubation, but direct laryngoscopy failed secondary to extensive bleeding despite aggressive suctioning. A size 3 classic LMA was placed, but had an audible leak with application of positive pressure. There was one failed attempt to blindly place an ETT through the cLMA. The cLMA was removed and replaced with a size 2.5 air-Q ILA. A cuffed 6.0 mm ID ETT was blindly inserted through the lumen of the air-Q ILA with confirmation via end-tidal capnography.

Discussion: Two children with airway bleeding who underwent failed intubation with direct laryngoscopy following rapid sequence induction were presented. In these instances, avoidance of a surgical airway was accomplished by using a supraglottic airway device. Several of these devices are used in daily practice, including the cLMA and proseal LMA. The combination of pediatric sizing, and the capability to easily pass a cuffed endotracheal tube blindly, makes the air-Q ILA very useful in this setting. The air-Q ILA served as a useful tool for rescue ventilation followed by expedient passage of an appropriately sized endotracheal tube. This device may overcome some of the limitations associated with traditional LMA assisted tracheal intubation (5).

Refs:
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4. Wong DT et al., Can J Anaesth, 2009

Jagannathan N et al., Paediatr Anaesth, 2009
The Air-Q® Self-Pressurizing Intubating Laryngeal Airway: A Report of the First 100 Uses in Adult Patients

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University of Wisconsin School of Medicine and Public Health, Madison, Wisconsin, United States

Introduction: The air-Q® Self-Pressurizing (SP) Intubating Laryngeal Airway (aILA-SP, Mercury Medical, Clearwater, FL) is a new supraglottic airway device designed for use as a primary airway and as an intubation conduit. Its overall design is identical to the reusable air-Q® Intubating Laryngeal Airway (aILA), except for the incorporation of an orifice between the air tube and cuff, which allows the cuff pressure to self-regulate during spontaneous and positive pressure ventilation. Thus, the pilot balloon and need for manual cuff inflation have been eliminated. Our primary aim is to describe our initial clinical experience with the aILA-SP in adults undergoing general anesthesia.

Methods: After approval by the Minimal Risk IRBs of both the University of Wisconsin (Madison, WI) and the University of Washington (Seattle, WA), we performed a retrospective chart review. Patients were included if an aILA-SP was used as the primary airway or as an intubating conduit. Patient, device, and device performance characteristics were abstracted. Data are reported as n (%), mean ± SD, or median (range) unless otherwise noted.

Results: One hundred patients undergoing elective surgical or radiologic procedures were included. Patient and procedure characteristics are presented in Table 1. Device and device performance characteristics are presented in Table 2. As a primary airway, acceptable performance was achieved in greater than 95% of cases. As a conduit, intubation via the aILA-SP was achieved in 97% of cases. Two failed attempts at blind intubation through the device were rescued by fiberoptic-aid. One patient could not be intubated via the aILA-SP due to periglottic tissue obstruction.

Discussion: We report the first series of adult patients in whom the aILA-SP was used during general anesthesia. Overall, the aILA-SP was simple to place, generated an average airway seal pressure (ASP) > 20 cmH₂O, and provided acceptable airway maintenance in greater than 95% of cases. As an intubation conduit, an adequate glottic view to allow successful intubation, particularly using a fiberoptic-aided technique, is present the majority of the time. Although the ASP is lower than that previously reported for the aILA,1-2 insertion is likely quicker, while its dynamically adjusting cuff may reduce airway morbidity. Further evaluation of its use, including attention to airway morbidity, is ongoing.


Figure 1
Table 1. Patient and Procedure Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yrs</td>
<td>40 ± 15</td>
</tr>
<tr>
<td>Gender, %</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>57</td>
</tr>
<tr>
<td>F</td>
<td>43</td>
</tr>
<tr>
<td>Height, cm</td>
<td>170 ± 12</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>82 ± 19</td>
</tr>
<tr>
<td>BMI, kg.m⁻²</td>
<td>28 ± 5</td>
</tr>
<tr>
<td>ASA, median</td>
<td>2 (1 - 3)</td>
</tr>
<tr>
<td>Surgery, %</td>
<td>Orthopedic</td>
</tr>
<tr>
<td></td>
<td>Urologic</td>
</tr>
<tr>
<td></td>
<td>General surgical</td>
</tr>
<tr>
<td></td>
<td>Ophthalmology</td>
</tr>
<tr>
<td></td>
<td>Gynecologic</td>
</tr>
<tr>
<td></td>
<td>ENT</td>
</tr>
<tr>
<td></td>
<td>Radiology (MRI)</td>
</tr>
<tr>
<td></td>
<td>Plastics</td>
</tr>
<tr>
<td></td>
<td>Vascular</td>
</tr>
</tbody>
</table>

Figure 2
Table 2: Device and Device Performance Characteristics

<table>
<thead>
<tr>
<th>Device size, %</th>
<th>2.5</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.5</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>4.5</td>
<td>61</td>
</tr>
</tbody>
</table>

| ASB, cm² | 24 ± 7 |

| Insertion attempts, % | 1 | 96 |
|                       | 2 | 3  |
|                       | 3 | 1  |

| Ease of insertion, % | easy | 87  |
|                      | slight difficulty | 12 |
|                      | moderate difficulty | 1  |
|                      | impossible | 0   |

| Glottic view, n (%) | 1 | 31 (72%) |
|                    | 2 | 11 (20%) |
|                    | 3 | 1 (2%)   |
|                    | 4 | 0 (0%)   |

| Intubation success, n (%) | Overall | 28 (97%) |
|                          | Blind   | 6 (67%)  |
|                          | FOB-guided | 21 (55%) |

ASB = airway seal pressure; 1 = full view of vocal cords, 2 = partial view of vocal cords or arytenoids, 3 = epiglottis only, 4 = no laryngeal structures visible.
A randomized comparison between the i-gel™ and the air-Q™ supraglottic airways when used by anesthesiology trainees as conduits for tracheal intubation in children

Comparaison randomisée entre les voies aériennes supraglottiques i-gel™ et air-Q™ quand elles sont utilisées par des résidents en anesthésiologie comme conduits pour intubation trachéale chez des enfants

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Abstract

Purpose Supraglottic airways are commonly used as conduits for fibreoptic bronchoscopy (FOB)-guided intubation in pediatric patients. We hypothesized that anesthesiology trainees with limited prior experience with FOB-guided intubation through a supraglottic airway in children would intubate the trachea faster through the air-Q™ supraglottic airway than through the i-gel™.

Methods Ninety-six children aged one month to six years were randomized to receive either the i-gel or air-Q for FOB-guided tracheal intubation by anesthesiology trainees. Time for successful tracheal intubation was the primary endpoint. Secondary endpoints included: time for device insertion, number of attempts for successful device insertion, airway leak pressures, FOB grade of laryngeal view, total number of attempts for tracheal intubation, time for removal of the device after tracheal intubation, and associated complications.

Results The median (interquartile range [IQR]) times to successful tracheal intubation for the air-Q (62.5 [47.9-77] sec) and the i-gel (55.9 [48.5-81.8] sec) were not significantly different (median difference 6.6 sec; 95% confidence interval [CI] -13.3 to 8.7; P = 0.53). The median (IQR) time to insertion for the air-Q (16.7 [14.4-20.0] sec) was shorter than for the i-gel (19.6 [16.7-23.0] sec) (median difference 2.9 sec; 95% CI 0.8 to 4.7; P = 0.005). There were no differences between devices with respect to airway leak pressures, success rates, and time to removal. Compared with the air-Q, the i-gel was associated with more problems during device removal after tracheal intubation, including breakage of the tracheal tube pilot balloon (n = 0 vs n = 13, respectively; P < 0.001), inadvertent extubation (n = 1 vs n = 5, respectively; P < 0.001), and difficulty controlling the tracheal tube (n = 0 vs n = 21, respectively; P < 0.001).


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Conclusions Contrary to our hypothesis, both the air-Q and i-gel supraglottic airways served as effective conduits for FOB-guided tracheal intubation in children when performed by trainees with limited prior experience. The i-gel, however, was associated with more problems during device removal following tracheal intubation. This study was registered at http://clinicaltrials.gov/show/NCT02189590.

Résumé

Objectif Les voies aériennes supraglottiques sont fréquemment utilisées comme conduits pour la intubation guidée par bronchoscopie à fibre optique (FOB) chez les patients pédiatriques. Nous avons formulé l’hypothèse que des résidents en anesthésiologie n’ayant qu’une expérience antérieure limitée de l’intubation guidée par FOB via une voie aérienne supraglottique chez des enfants, intubaient la trachée plus rapidement avec la voie aérienne supraglottique air-QTM qu’avec l’i-gelTM.

Méthodes Quatre-vingt-seize enfants âgés d’un mois à six ans ont été randomisés pour recevoir une intubation trachéale guidée par FOB avec l’i-gel ou l’air-Q par des résidents en anesthésiologie. Le critère d’évaluation principal était le temps nécessaire à la réussite de l’intubation trachéale. Les critères d’évaluation secondaires incluaient : le temps d’insertion du dispositif, le nombre de tentatives nécessaires à une insertion réussie du dispositif, les pressions de fuite de la voie aérienne, le grade FOB de la vue laryngée, le nombre total de tentatives d’intubation trachéale, le temps nécessaire au retrait du dispositif après l’intubation trachéale, et les complications associées.

Résultats Les temps médians (intervalle interquartile [IQR]) de réussite de l’intubation trachéale avec l’air-Q (62,5 [47,9-77] sec) ou l’i-gel (55,9 [48,5-81,8] sec) n’ont pas été significativement différents (différence médiane : 6,6 sec; intervalle de confiance [IC] à 95% : -13,3 à -8,7; P < 0,53). Le temps médian (IQR) d’insertion a été plus court avec l’air-Q (16,7 [14,4-20,0] sec) qu’avec l’i-gel (19,6 [16,7-23,0] sec) (différence médiane 2,9 sec; IC à 95% : 0,8 à 4,7; P < 0,005). Il n’y a pas eu de différences entre les dispositifs sur les plans des pressions de fuite de la voie aérienne, des taux de succès et des temps de retrait. Comparativement à l’air-Q, l’i-gel a été associé à davantage de problèmes au cours du retrait du dispositif après l’intubation trachéale, incluant le bris du ballonnet du tube trachéal (respectivement, n = 0 contre n = 13; P < 0,001), l’extubation accidentelle (respectivement, n = 1 contre n = 5; P < 0,001), et la difficulté à contrôler le tube trachéal (respectivement, n = 0 contre n = 21; P < 0,001).

Conclusions Contrairement à notre hypothèse, les voies aériennes supraglottiques air-Q et i-gel ont toutes les deux servi de conduits efficaces pour l’intubation trachéale guidée par FOB chez des enfants quand l’intubation était pratiquée par des résidents ayant une expérience antérieure limitée. L’i-gel a toutefois été associé à davantage de problèmes au cours du retrait du dispositif après intubation trachéale. Cette étude a été enregistrée sur le site http://clinicaltrials.gov/show/NCT02189590.
assessed secondary outcomes, including the time and success of SGA placement, airway leak pressure, FOB grade of laryngeal view, and the time for removal of the device after successful tracheal intubation.

Methods

The Institutional Review Board of the Stanley Manne Children’s Research Institute approved this study in June 2014. Written informed consent was obtained from the guardians of all patients. Ninety-six children (American Society of Anesthesiologists physical status I-III, aged one month to six years) scheduled for elective surgery under general endotracheal anesthesia were enrolled in this study. Children with active upper respiratory infections, significant pulmonary disease, a known history of and/or suspicion of a difficult airway, or airway abnormalities were not enrolled in the study.

A computer-generated randomization was utilized for SGA assignment (i-gel or air-Q) and was revealed to the study investigator just prior to device placement. Only cuffed endotracheal tubes (ETT) were utilized in this study (Mallinckrodt Inc.; St Louis, MO, USA). All SGA placements, FOB-guided tracheal intubations, and removal of the SGA after intubation were performed by anesthesia trainees. An anesthesia trainee was defined as a resident or fellow from clinical anesthesia (CA) years 2, 3, or 4 who had not previously performed FOB-guided tracheal intubation through an SGA in children. All trainees participating in the study were volunteers and their prior experience with FOB-guided tracheal intubation was verified through their case logs. Before participating, the trainees received a brief lecture and viewed a video outlining the steps for FOB-guided tracheal intubation through an SGA. Two expert study investigators were involved with each patient: one to ensure standardization of methodology between patients, and the other to supervise the anesthesia trainee closely and to offer verbal cues and airway maneuvers if needed.

All patients received general anesthesia with inhalation induction using nitrous oxide 70% in 30% oxygen and 8% sevoflurane. An intravenous cannula was placed, and rocuronium 0.6 mg·kg\(^{-1}\) \(\text{iv}\) was administered. Nitrous oxide was then discontinued, and sevoflurane was maintained with an end-tidal concentration of 3% and an end-tidal oxygen concentration greater than 90% prior to SGA insertion.

Supraglottic airway insertion

Both devices were placed using a standard midline insertion technique. Device size was chosen based on the manufacturer’s guidelines. The time for device insertion started with the removal of the facemask and ended when end-tidal carbon dioxide was observed. For the air-Q, intracuff pressure was standardized to 40 cm H\(_2\)O using a cuff pressure gauge. Successful placement was confirmed with the ability to achieve tidal volumes of at least 7 mL·kg\(^{-1}\) and a square-wave capnogram. The airway leak pressure was measured with the expiratory valve closed and a fresh gas flow of 3 L·min\(^{-1}\) until equilibrium was seen on the pressure gauge.\(^{18}\) The trainees were allowed a maximum of three attempts to place the SGA successfully. The number of attempts for placement and problems during placement (changing device size, downward traction, and spontaneous dislodgement) were also recorded.

Tracheal intubation through the SGA

All FOB-guided tracheal intubations through the SGA were performed with a video tower to visualize the intubation process on an external monitor. Three separate times were then measured by a study investigator, all beginning with the removal of the facemask: (1) Time to first glottic view: defined as the duration of time ending with the first view of the glottic opening. (2) Time to carinal view: defined as the duration of time ending with visualization of the carina. (3) Time to successful tracheal intubation: defined as the duration of time ending with the confirmation of end-tidal carbon dioxide after successful tracheal intubation. One of the study investigators used a previously published scale to grade the FOB view of the larynx through the SGA just proximal to the ventilating orifice.\(^{19}\)

The trainee was allowed a total of three attempts for successful FOB-guided tracheal intubation. The patient’s lungs were ventilated through the SGA between attempts, and the time was restarted between each attempt. A failed attempt was defined as any evidence of oxygen desaturation (Sp\(_{O_2}\) < 90%), any time the bronchoscope had to be withdrawn completely from the SGA, (i.e., secretions, disorientation, or oxygen desaturation), or requiring more than three minutes per attempt.\(^{1}\)

Airway maneuvers, such as jaw thrust, neck extension/flexion, or anterior laryngeal pressure, were allowed to improve the laryngeal grade of view and/or to facilitate passage of the tracheal tube. These maneuvers were performed only by the study investigators if indicated (suboptimal laryngeal view/resistance to tracheal tube passage), and the total number of maneuvers needed was recorded. The number of cues needed was also recorded. Verbal cues were offered when prompted by the trainee if disorientation occurred (i.e., if the attending anesthesiologist viewed the red opaque screen and observed that the trainee made no purposeful movement with the bronchoscope) or if there was difficulty in tracheal...
tubepassage. The verbal cues offered by the attending anesthesiologist were standardized.

Removal of the SGA

Following successful tracheal intubation, the SGA was removed using a second ETT as a stabilizing rod. The time for removal of the device started with the disconnection of the breathing circuit and ended when end-tidal carbon dioxide was observed. The number of verbal cues needed during the removal process was recorded. Each trainee then scored the process of removing the SGA after tracheal intubation on a subjective scale of 1-4 (1 = no difficulty; 2 = mild difficulty; 3 = moderate difficulty; 4 = severe difficulty). Problems encountered during SGA removal were recorded, including difficulty in controlling the tracheal tube, pilot balloon breakage, or inadvertent extubation. If needed, broken pilot balloons would be repaired using a 22G angiocatheter attached to a one-way valve inserted into the inflation line.20

The trachea would be intubated by direct laryngoscopy if correct SGA placement was not achieved within three attempts, FOB intubation, through the device, was not successful after three attempts, or the ETT was dislodged during SGA removal. At the end of the surgical procedure, the ETT was removed after standard extubation criteria were met. Perioperative complications such as oxygen desaturation, laryngospasm, and bronchospasm were also recorded.

The primary outcome measure of this study was the time to successful tracheal intubation. Group sample sizes of 48 each would achieve 90% power to reject the null hypothesis of equal means when the mean difference between SGAs is 20.0 sec (minimum clinically accepted difference), with a standard deviation of 30.0 sec and an alpha of 0.05 using a two-sided two-sample equal-variance Student’s t test. Power analysis was performed using PASS version 12 (NCSS, LLC; Kaysville, UT, USA).

Intraoperative data were recorded using a standardized data collection sheet, entered into a database using Microsoft® Excel® 2010, and then imported into Stata® 12 software (StataCorp LP, College Station, TX, USA) for statistical analysis. The median [IQR] was calculated for demographic data and for non-normally distributed continuous and ordinal variables, including time for SGA placement, time to intubation, number of attempts, number of airway maneuvers, and time for SGA removal. Comparisons of times to intubation were performed using the Mann-Whitney U test. Frequencies and percentages were calculated for categorical variables and compared between groups using Fisher’s exact test. All reported P values are two sided.

Results

Twenty-four trainees participated in this study (CA-2 = 12, CA-3 = 6, CA-4 = 6) from July to August 2014. Demographics are presented in Table 1.

A CONSORT diagram representing the flow of patients is shown in the Figure.

All SGAs were placed on the first attempt. The median [IQR] time for successful placement with the air-Q was faster than with the i-gel (16.7 [14.4-20.0] sec vs 19.6 [16.7-23.0] sec, respectively; median difference 2.9 sec; 95% CI 0.8 to 4.7; P = 0.005). The i-gel was associated with more problems during placement (Table 2). No differences were found in the times to the first glottic view or the carinal view. Similarly, for our primary endpoint, the overall median [IQR] time to tracheal intubation was not different between the devices (air-Q, 62.5 [47.9-77] sec vs i-gel, 55.9 [46.5-81.8] sec; median difference 6.6 sec; 95% confidence CI -13.3 to 8.7; P = 0.53). Also, no differences were found in the number of attempts, fibreoptic grades of view, maneuvers for passage of the tracheal tube, or verbal cues offered (Table 3).

Time for removal of the SGA did not differ between devices, but the i-gel was associated with more problems during removal (Table 4). Outright failure of FOB-guided tracheal intubation occurred in two children in the air-Q group (inability to intubate the trachea within three attempts). In both cases, direct laryngoscopy was used to intubate the trachea without difficulty. Direct laryngoscopy

Table 1 Patient characteristics

<table>
<thead>
<tr>
<th></th>
<th>air-Q (n = 48)</th>
<th>i-gel (n = 48)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>2.2 [1-4]</td>
<td>2.2 [1-4]</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>12.3 [9.6-15.3]</td>
<td>12.8 [9.0-17.5]</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>84.5 [73-104]</td>
<td>90 [74-104]</td>
</tr>
<tr>
<td>ASA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>22 (45.8)</td>
<td>29 (60.4)</td>
</tr>
<tr>
<td>II</td>
<td>14 (29.2)</td>
<td>14 (29.2)</td>
</tr>
<tr>
<td>III</td>
<td>12 (25.0)</td>
<td>5 (10.4)</td>
</tr>
</tbody>
</table>

Values are presented as median [IQR] or counts (percentages) as appropriate.
IQR = interquartile range.
ASA = American Society of Anesthesiologists.
was used to intubate the trachea without difficulty in six patients where the ETT was dislodged during SGA removal (n = 2, i-gel size 1.5; n = 3, i-gel size 2.0; and n = 1, air-Q size 1.5).

There was no significant difference in the complication rates between the two devices. Transient oxygen desaturation (SpO₂ < 90%) occurred during FOB tracheal intubation in five patients (n = 1, i-gel; n = 4, air-Q). During removal of the SGA, transient desaturation occurred in two patients in the air-Q group. There were no instances of regurgitation, laryngospasm, or bronchospasm.

**Discussion**

The main finding in this study was that both the air-Q and i-gel supraglottic airways served as effective conduits for FOB-guided tracheal intubation in children when performed by trainees with limited prior experience. The i-gel, however, was associated with more problems during placement and device removal following tracheal intubation.

The three tracheal intubation time points observed in this study did not differ between the two devices in the

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**Table 2** Comparison of SGA placement and fiberoptic bronchoscopy grade of view

<table>
<thead>
<tr>
<th>Measure</th>
<th>air-Q (n = 48)</th>
<th>i-gel (n = 48)</th>
<th>P value</th>
<th>Median Differences (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of attempts for successful placement</td>
<td>1 [1-1]</td>
<td>1 [1-1]</td>
<td>0.55</td>
<td>0 (0 to 0)</td>
</tr>
<tr>
<td>Time to successful placement (sec)</td>
<td>16.7 [14.4-20.0]</td>
<td>19.6 [16.7-23.0]</td>
<td>0.01</td>
<td>2.9 (0.8 to 4.7)</td>
</tr>
<tr>
<td>Leak pressure, cm H₂O</td>
<td>17 [14-21]</td>
<td>18 [14-24]</td>
<td>0.35</td>
<td>1 (1.5 to 3.8)</td>
</tr>
<tr>
<td>Total patients having problems during SGA placement, n (%):</td>
<td>1 (2.1)</td>
<td>7 (14.6)</td>
<td>0.06</td>
<td>-12.5% (25 to 0.3)</td>
</tr>
<tr>
<td>Spontaneous dislodgement</td>
<td>1 (2.1)</td>
<td>3 (6.3)</td>
<td>0.61</td>
<td>-4.2% (14.2 to 5)</td>
</tr>
<tr>
<td>Downward traction needed</td>
<td>0</td>
<td>5 (10.4)</td>
<td>0.06</td>
<td>-10.4% (21 to 0.3)</td>
</tr>
<tr>
<td>Size change needed</td>
<td>0</td>
<td>1 (2.1)</td>
<td>1.0</td>
<td>-2.1% (8 to 4)</td>
</tr>
<tr>
<td>Fibreoptic Grade of view, n (%):</td>
<td></td>
<td></td>
<td>0.90</td>
<td>-</td>
</tr>
<tr>
<td>1</td>
<td>18 (37.5)</td>
<td>19 (39.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>10 (20.8)</td>
<td>11 (22.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>6 (12.5)</td>
<td>9 (18.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>9 (18.8)</td>
<td>6 (12.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>5 (10.4)</td>
<td>3 (6.3)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Values are median [interquartile range] or counts (percentages) as indicated. Fibreoptic grade of view: 1, larynx only seen; 2, larynx and epiglottis posterior surface seen; 3, larynx and epiglottis tip of anterior surface seen, < 50% visual obstruction of epiglottis to larynx; 4, epiglottis downfolded and its anterior surface seen, > 50% visual obstruction of epiglottis to larynx; 5, epiglottis downfolded and larynx cannot be seen directly. CI = confidence interval; SGA = supraglottic airway
hands of the trainees. Although the overall times for successful tracheal intubation in this study were slower than previous trials with the air-Q and other SGAs by experts, they are still within acceptable clinical limits for FOB-guided tracheal intubation times in children. It has been shown in previous studies that the i-gel is associated with better FOB grades of view in children when compared with the LMA-Classic and LMA-ProSeal. In this study, we did not show a difference between the two devices in regard to FOB grades of view. The overall successful rates of tracheal intubation suggest that tracheal intubation through an SGA is a relatively straightforward process, even with limited prior experience.

Although the time for successful placement of the device was faster with the air-Q, this difference may not be clinically significant. Additionally, this difference may be related to the greater number of issues associated with the i-gel, as evidenced by spontaneous dislodgement and the

<table>
<thead>
<tr>
<th>Time to first glottic view (sec)</th>
<th>air-Q (&lt;i&gt;n&lt;/i&gt; = 48)</th>
<th>i-gel (&lt;i&gt;n&lt;/i&gt; = 48)</th>
<th>&lt;i&gt;P&lt;/i&gt; value</th>
<th>Median Differences (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.7 [8.6-20.0]</td>
<td>11 [7.0-20.2]</td>
<td>0.33</td>
<td>1.7 (-6.1 to 3.0)</td>
<td></td>
</tr>
<tr>
<td>Time to carinal view (sec)</td>
<td>34 [23.4-49.2]</td>
<td>28.8 [18.5-46.1]</td>
<td>0.16</td>
<td>5.2 (-13.1 to 5.8)</td>
</tr>
<tr>
<td>Time to successful intubation (sec)</td>
<td>62.5 [47.9-77.0]</td>
<td>55.9 [46.5-81.8]</td>
<td>0.53</td>
<td>6.6 (-13.3 to 8.7)</td>
</tr>
<tr>
<td>Number of attempts for successful placement (&lt;i&gt;n&lt;/i&gt; (%)</td>
<td>1</td>
<td>37 (77.1)</td>
<td>38 (79.2)</td>
<td>0.41</td>
</tr>
<tr>
<td>2</td>
<td>9 (18.8)</td>
<td>8 (16.7)</td>
<td>0.41</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>2 (4.2)</td>
<td>0.41</td>
<td>-</td>
</tr>
<tr>
<td>Failure</td>
<td>2 (4.2)</td>
<td>0</td>
<td>0.41</td>
<td>-</td>
</tr>
<tr>
<td>Time to carinal view (sec)</td>
<td>34 [23.4-49.2]</td>
<td>28.8 [18.5-46.1]</td>
<td>0.16</td>
<td>5.2 (-13.1 to 5.8)</td>
</tr>
<tr>
<td>Time to successful intubation (sec)</td>
<td>62.5 [47.9-77.0]</td>
<td>55.9 [46.5-81.8]</td>
<td>0.53</td>
<td>6.6 (-13.3 to 8.7)</td>
</tr>
<tr>
<td>Number of attempts for successful placement (&lt;i&gt;n&lt;/i&gt; (%)</td>
<td>1</td>
<td>37 (77.1)</td>
<td>38 (79.2)</td>
<td>0.41</td>
</tr>
<tr>
<td>2</td>
<td>9 (18.8)</td>
<td>8 (16.7)</td>
<td>0.41</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>2 (4.2)</td>
<td>0.41</td>
<td>-</td>
</tr>
<tr>
<td>Failure</td>
<td>2 (4.2)</td>
<td>0</td>
<td>0.41</td>
<td>-</td>
</tr>
<tr>
<td>Number of maneuvers for tracheal tube passage</td>
<td>0 [0-0]</td>
<td>0 [0-1]</td>
<td>0.13</td>
<td>0 (0 to 1)</td>
</tr>
<tr>
<td>Number of verbal cues needed for successful tracheal intubation</td>
<td>0.31</td>
<td>-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Values are median [interquartile range] or counts (percentages) as indicated

<table>
<thead>
<tr>
<th>Time for removal, sec</th>
<th>air-Q (&lt;i&gt;n&lt;/i&gt; = 46)</th>
<th>i-gel (&lt;i&gt;n&lt;/i&gt; = 48)</th>
<th>&lt;i&gt;P&lt;/i&gt; value</th>
<th>Median Differences (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>35.0 [28.6-41.9]</td>
<td>32.6 [25.5-49.2]</td>
<td>0.91</td>
<td>2.4 (-5.6 to 8.6)</td>
<td></td>
</tr>
<tr>
<td>Difficulty for SGA removal (%)</td>
<td>No difficulty</td>
<td>25 (54.4)</td>
<td>21 (43.8)</td>
<td>0.58</td>
</tr>
<tr>
<td>Mild difficulty</td>
<td>14 (30.4)</td>
<td>16 (33.3)</td>
<td>0.58</td>
<td>-</td>
</tr>
<tr>
<td>Moderate difficulty</td>
<td>6 (13.0)</td>
<td>7 (14.6)</td>
<td>0.58</td>
<td>-</td>
</tr>
<tr>
<td>Severe difficulty</td>
<td>1 (2.2)</td>
<td>4 (8.3)</td>
<td>0.58</td>
<td>-</td>
</tr>
<tr>
<td>Number of verbal cues needed for removal of SGA (%)</td>
<td>0</td>
<td>30 (65.2)</td>
<td>31 (64.6)</td>
<td>0.66</td>
</tr>
<tr>
<td>1</td>
<td>8 (17.4)</td>
<td>9 (18.7)</td>
<td>0.66</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>6 (13.0)</td>
<td>8 (16.7)</td>
<td>0.66</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>2 (4.4)</td>
<td>0</td>
<td>0.66</td>
<td>-</td>
</tr>
<tr>
<td>Problems during SGA removal (%)</td>
<td>1 (2.1)</td>
<td>29 (60.4)</td>
<td>&lt;0.001</td>
<td>-</td>
</tr>
<tr>
<td>Pilot balloon breakage</td>
<td>0</td>
<td>*13 (27.1)</td>
<td>&lt;0.001</td>
<td>-</td>
</tr>
<tr>
<td>Inadvertent extubation/loss of control</td>
<td>1 (2.1)</td>
<td>*5 (10.4)</td>
<td>0.20</td>
<td>-</td>
</tr>
<tr>
<td>Difficulty controlling ETT during SGA removal</td>
<td>0</td>
<td>*21 (43.8)</td>
<td>&lt;0.001</td>
<td>-</td>
</tr>
</tbody>
</table>

Values are median [interquartile range] or counts (percentages) as indicated

* Some patients had more than one problem during removal (e.g., pilot balloon breakage + difficulty controlling ETT). SGA = supraglottic airway; ETT = endotracheal tube

hands of the trainees. Although the overall times for successful tracheal intubation in this study were slower than previous trials with the air-Q and other SGAs by experts, they are still within acceptable clinical limits for FOB-guided tracheal intubation times in children. It has been shown in previous studies that the i-gel is associated with better FOB grades of view in children when compared with the LMA-Classic and LMA-ProSeal. In this study, we did not show a difference between the two devices in regard to FOB grades of view. The overall successful rates of tracheal intubation suggest that tracheal intubation through an SGA is a relatively straightforward process, even with limited prior experience.

Although the time for successful placement of the device was faster with the air-Q, this difference may not be clinically significant. Additionally, this difference may be related to the greater number of issues associated with the i-gel, as evidenced by spontaneous dislodgement and the
need for continuous downward traction on the device, a finding also reported by other investigators.\textsuperscript{21–24} Despite these concerns, both devices had high insertion success rates. The insertion success rates are encouraging given the limited clinical experience of the anesthesia trainees with either device in children prior to this study. The leak pressures with the air-Q in this study are consistent with those in other studies using this device in children.\textsuperscript{10,12,25,26} The leak pressures of the i-gel appear to be lower than what has been reported in systematic reviews and meta-analyses in children.\textsuperscript{14,15} It is possible that operator inexperience may have contributed to the lower airway leak pressures associated with the i-gel.

Compared with the air-Q, the longer airway tube of the i-gel can be a disadvantage for purposes of tracheal intubation. If the airway tube of the SGA is nearly the same length as the ETT being utilized (i.e., size 1.5 i-gel with a 3.5 ETT), the ETT may or may not be adequately past the vocal cords during tracheal intubation, and this may also cause difficulties during removal of the device, including inadvertent tracheal extubation. The use of an airway exchange catheter or a double-tube assembly to create a “longer ETT” may help to overcome this challenge and decrease the risk of tracheal extubation.\textsuperscript{27} Another reasonable option may be to leave both the ETT and the i-gel in place until the conclusion of the procedure. The increased potential for tracheal extubation or pilot balloon breakage associated with SGAs that have relatively long/ narrow airway tubes should be a consideration when choosing a device to facilitate tracheal intubation in patients with a difficult airway. Therefore, the pilot balloon of the ETT should perhaps be electively removed (sizes 1 and 1.5 i-gel) when using cuffed tracheal tubes, especially if removal of the SGA is planned after tracheal intubation. This was also shown in a trial with the smaller-sized Ambu\textsuperscript{TM} and Aura–i\textsuperscript{TM} (Ambu USA Glen Burnie, MD USA) due to their narrower proximal airway tube.\textsuperscript{12} Also, the pediatric-sized LMA-Classic/ProSeal will not accommodate passage of the pilot balloon during removal.\textsuperscript{28} The wider airway tube of the air-Q allows passage of cuffed ETTs, including their pilot balloons, and its shorter length may decrease the risk of ETT dislodgment during the device removal process.\textsuperscript{10,12}

Although it was not tested in this study, a theoretical advantage of the i-gel would be the ability to evacuate gastric contents (except size 1 devices), a feature that is not available with the air-Q. This feature may be useful if airway rescue is required in a patient with a “full stomach” with subsequent need for tracheal intubation.

There were several limitations to this study. First, we studied children with only normal airways, and our results may not apply to children with difficult airways. Second, the clinical performance of these devices was tested in the hands of trainees, and these results may differ in the hands of experts. Third, the expert study investigators were allowed to offer verbal cues to aid the trainees; therefore, the results may not truly represent novices performing FOB-guided tracheal intubations on their own without instructive assistance. Finally, data collection was not blinded to the outcome assessors.

The i-gel may be an acceptable alternative to the air-Q as a conduit for FOB-guided tracheal intubation in children in terms of timing outcomes. Nevertheless, when using a cuffed ETT through the i-gel, appropriate precautions for i-gel removal must be considered because of its longer and relatively narrower airway tube. When compared with the i-gel, the air-Q permits the passage of a cuffed ETT and provides a relatively easy process for removal of the device after tracheal intubation. For these practical advantages, the air-Q may be preferred over the i-gel as a conduit for tracheal intubation in children.

Disclosure None of the authors have any affiliations that may be perceived to be conflicts of interest with the submitted material.

References


Research Article

The use of AIR-Q as conduit for fiberoptic endotracheal intubation in adult paralyzed patients

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KEYWORDS
Air Q; Intubating laryngeal mask; Supraglottic device; Fiberoptic intubation through Air Q; Airway management

Abstract
Background: The AIR-Q Laryngeal Mask (Cookgas LLC; distributed by Mercury Medical) is a supraglottic device present in the market since 2004. It has different sizes for pediatric and adult use. This device proved to be of utmost importance in the management of difficult airway [1]. The study evaluates the different adult sizes of the Air Q when used for intubation regarding the ease of insertion, the laryngeal view grade, their efficacy as conduit for standard cuffed endotracheal tubes using fiberoptic bronchoscope. The study also records the time of intubation, the ease and time of removal of the AIRQ over a removal stylet without dislodgement of the tube from trachea. Any complications related to the use of AIRQ were also recorded such as laryngeal oedema, blood streaked mucous, trauma to the airway, laryngeal spasm or aspiration.

Methods: Sixty adult patients aged 20–50 years, ASA I, II undergoing elective surgeries requiring general anesthesia, were enrolled in the study. The patients were divided into 2 equal groups according to their body weight. The body weight of the first group ranged from 50 to 70 kg and used the Air Q 3.5 for intubation with an endotracheal tube (ETT) 7 mm ID, while the body weight of the second group ranges from 70 to 100 kg and used the Air Q 4.5 for intubation with a tube 7.5 mm ID. The number of attempts of insertion, the seal pressure, the laryngeal view grade, the time and the number of attempts of intubation, time of removal of the AIRQ over the tube without dislodgement, and any complications related to the use of AIRQ were recorded such as laryngeal oedema, blood streaked mucous, trauma to the airway, laryngeal spasm or aspiration.

Results: The insertion and removal of the AIRQ were easy and successful in all patients of both groups. The endotracheal intubation by fiberoptic bronchoscope through the Air Q was successful.
and easy in both groups. Grade 5 laryngeal view was seen with AIRQ 4.5 in some patients with higher body weight. 

Conclusion: The insertion of AIRQ in adult patients is easy and provides an effective conduit for the standard cuffed endotracheal tubes using fiberoptic bronchoscope. The removal of the AIRQ over the removal stylet is easy without dislodgement of the tube. Because of higher incidence of down folding of the epiglottis in some obese patients, they are better intubated under direct vision with the use of fiberoptic bronchoscope.

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1. Introduction

The AIRQ is a supra glottic device used as conduit for intubation in the last few years. In contrast to Intubating (fastrach) LMA (ILMA), it allows the passage of standard cuffed endotracheal tubes. The maximum size ETT is 7.5 mm ID for Air Q 3.5, and 8.5 mm ID for Air Q 4.5. The ILMA has three sizes; 3, 4, 5. It allows for passage of five different sizes of special endotracheal tubes (6–6.5–7–7.5 and 8 mm ID) [1]. The commonly used classic LMA number 3 allows for passage of 5 mm ID ETT, and the maximum size LMA number 6 allows passage of ETT 7 mm ID [2].

The AIR-Q Laryngeal Mask (Cookgas LLC; distributed by Mercy Medical) is a c pre-shaped intubating laryngeal airway easy to use, with a rapid learning curve. The inner diameter of the airway is wide and oval allowing easy passage of the standard endotracheal tube. The keyhole opening present within the opening guides the tube into the larynx. The AIR-Q is then removed over removal stylet. Reusable and disposable AIR-Qs are available in the market [1].

Compared to classic LMA, the AIR-Q has a removable international connection, bite block, short airway tube for easy manipulation during removal of the AIR-Q over the removal stylet, and a smaller air volume for cuff inflation. There are three internal ridges located in anterior part of the cup to create airway stability. When the cuff is inflated, these ridges move against the posterior larynx and improve the anterior mask seal, isolate the esophagus and reduce the incidence of aspiration. The semi inflated anterior part of the wide cup minimizes the folding back of the cup tip during insertion. The presence of a hole on the top of the keyhole opening allows ventilation if the main airway opening is blocked by the long epiglottis.

Comparing the AIR-Q to the ILMA, it is made of silicone with no metal parts in it. So it is used as ventilatory device as well as a conduit for ETT, in contrast to ILMA, which is used only for intubation [3].

The ILMA has only three sizes for single or reusable use (3, 4, 5), and cannot be used for patients below 30 kg. AIRQ has six different disposable sizes (1–1.5–2–2.5–3.5–4.5), and 4 reusable sizes which are present in the market now (1.5–2.5–3.5–4.5) [3–5].

2. Objectives

The main objectives of work first to assess the ease of insertion of the different adult AIRQ sizes 3.5 and 4.5 in patients according to their body weight, second to record the laryngeal view grade, third is to assess the ability to intubate through it by fibroscope, fourth to assess the ease and success rate of its removal over the removal stylet without dislodgement of the endotracheal tube. Lastly to record the presence of any complications related to the use of AIRQ in the oral cavity as laryngeal oedema, blood streaked mucous, trauma to the airway, laryngeal spasm or aspiration.

3. Materials and methods

The study was performed in kasr Einy learning hospital, Cairo University, Egypt from 1/10/2011 to 1/4/2012. All patients were intubated by experienced personnel proficient with fiberoptic and AIR-Q insertion.

After approval of ethical committee and written informed consent from the patients, 60 adult patients, were enrolled in the study.

Exclusion criteria were ASA > II, airway score ≥ 5 (Ganzouri airway scoring system) [6,7]. Patients < 20 or > 50 years, body weight < 50 or > 100 kg, any anatomical abnormalities in the head and neck that affect the airway, any active chest or cardiac condition, or any gastric problems increasing incidence of regurgitation and aspiration.

Inclusion criteria include patient’s age 20–50 years, body weight 50–100 kg. ASA I, II and AWS < 5 evaluated by Ganzouri AWSS. No anatomical abnormalities in the head and neck. No active chest or cardiac condition preventing safe general anesthesia, and no gastric problems that may increase the incidence of regurgitation and aspiration.

All patients included in the study were intubated using fiberoptic bronchoscope through the intubating AIR-Q. The size of the AIRQ was used according to body weight referred to manufacture’s guidelines.

The patients were divided into 2 groups according to the body weight. Group 3.5 Includes patients with body weight 50–70 kg, and group 4.5 includes patients 70–100 kg body weight. In the pre-anesthetic room, the AWS was calculated for each patient according to Ganzouri AWSS described in Table 1.

An intravenous (IV) cannula was inserted in a peripheral vein, 1 mg atropine, and 2 mg midazolam were given IV 5 min prior to induction of general anesthesia. In the operating room, all standard monitors were connected to the patient including pulse oxymeter, electrocardiogram, and non-invasive blood pressure. 100% oxygen mask was given to patient by face mask. Anesthesia was started by IV Fentanyl 1 µg/kg, propofol 2 mg/kg, and atracurium 0.5 mg/kg. Mechanical ventilation was allowed for at least 3 min together with inhalation of isoflurane at 1 MAC. Adequate muscle relaxation was tested by peripheral nerve stimulator with Train Of Four (TOF) stimuli. When TOF ratio is 0; the proper size semi inflated AIR-Q was inserted by classical method, the cuff was inflated according the manufacture’s recommendations.
The number of attempts of insertion was recorded until it became fit around the larynx without air leak. If the Air-Q was not fitting in place, it was manipulated from the neck to put it in best position to allow adequate tidal volume 5–6 ml/kg, without air leak. The Air-Q was then connected to the ventilator. The peak airway pressure was not allowed to increase more than 25 cm H₂O. The leak pressure was calculated by closing the expiratory valve, stopping ventilation and keeping the patient apneic, with the oxygen flow at 5 L/min. The gradual rise in the pressure gauge was observed until an audible noise was heard from the AIR-Q due to release of pressure. This pressure point is recorded as the leak test pressure [8].

After adequate oxygenation, the patient was disconnected from the ventilator, then the fiberoptic bronchoscope (Storz 3.7 mm) loaded with the tube was inserted through the AIR-Q to detect the laryngeal view grade that may ranged from 1 to 5 as follows; grade 1 = only larynx was seen, grade 2 = larynx plus the posterior surface of epiglottis were seen, grade 3 = larynx and anterior tip of epiglottis were seen with < 50% visual obstruction of larynx, grade 4 = epiglottis downfolded and its anterior surface were seen with > 50% visual field obstruction, and grade 5 = complete down folding of epiglottis and the larynx could not be seen directly [9,10].

![Figure 1](image)

**Figure 1** The laryngeal view grades are as such Grade 1: whole vocal cords are seen, the epiglottis is not seen at all. Grade 2: larynx plus the posterior surface of epiglottis are seen. Grade 3: the anterior tip of the epiglottis is seen. Grade 4: the anterior tip of the epiglottis is seen and encroaching on the view of vocal cords obstructing < 50% of view. Grade 5: the epiglottis is completely obstructing the AQ opening, no view is seen.
The time to removal of AIRQ is finally recorded from time of disconnection of the tube from the circuit to the time of reconnection again to the ventilator and capnogram after removal of the AIRQ. At the end of operation, the patients were extubated after complete recovery from muscle relaxant shown by TOF ratio 0.7. Any complications as blood streaked mucous, sore throat, laryngeal spasm, laryngeal oedema were recorded postoperatively.

4. Statistical data

Data were analyzed using the statistical software PASW statistics 19 (SPSS Inc., Chicago). Data is represented as Mean ± SD. Statistical comparison between the groups using student t test for continuous data, $X^2$ test for categorical data, and Mann Whitney U test for ordinal data, a spearman $p$ correlation coefficient was calculated for the relationship between the patient’s body weight and the fiberoptic laryngeal view grade. The Pearson correlation coefficient was calculated for the relationship between the patient’s body weight and the time for intubation.

5. Results

Sixty patients ASA I, II were enrolled in the study. No one was excluded from it. We studied 22 females and 38 males with a mean age of $37.3 ± 12.2$ years and mean body weight of $77 ± 12.5$ kg. There was significant difference in the body weight within both groups ($p < 0.001$). The patients were divided into two equal groups according to body weight. The demographic and descriptive characteristics were included in Table 2.

The airway score (AWS) was calculated for each patient. 21 patients had AWS 0 (35%), 7(11.7%) patients had AWS 1, 13(21.7%) patients had AWS 2, 10(16.7%) patients had AWS 3, 9(15%) patients had AWS 4 Table 1.

In the group 3.5, the AIRQ was inserted easily from the first time in all patients, while in 2 patients of group 4.5, there was some difficulties in insertion of the AIRQ that needed its reinsertion again until it became fit around the airway without any air leak, and this difference was significant between groups ($p < 0.001$).

For group 3.5 the mean leak pressure was $24 ± 2$ cm H$_2$O, while that for group 4.5 was $24.2 ± 1.9$ cm H$_2$O and this difference was non-significant.

The laryngeal view grades were as such:

- **Grade 1:** for group 3.5 22(73.3%) patients had grade 1 and 16(53.3%) patients in group 4.5.
- **Grade 2:** 4(13.3%) patients in each group.
- **Grade 3:** 2(6.7%) in group 3.5 and 3(10%) in group 4.5.
- **Grade 4:** 1(3.3%) patient in group 3.5, and 4(13.3%) patients in group 4.5.
- **Grade 5:** 1(3.3%) patient in group 3.5 and 3(10%) in group 4.5.

There was statistical and clinical significances between groups ($p < 0.01$).

The number of attempts of endotracheal intubation was recorded. At the beginning of the study, 2(6.7%) patients were intubated from the second time in group 3.5. In group 4.5 all patients (100%) were intubated from the first time.

The time of intubation was recorded from the time of introduction of the fiberscope through the AIRQ to the appearance of ETCO2 wave form after successful intubation. In group 3.5 the mean intubation time was $19.7 ± 3.8$ s while for group 4.5 it was $22.2 ± 6.4$ s and this difference was not statistically significant.

The time of removal of the AIR-Q was recorded from the time of attachment of the stylet to the tube till capnogram waveform reading after reconnection of the tube to the ventilator. For group 3.5 the mean time of removal was $21 ± 2.7$ s and for group 4.5 was $20.3 ± 3$ s and these findings were non-significant.

After removal of the AIR-Q, it was examined for blood stained mucous as a result of mucosal injury. Only one patient in group 4.5 (3.3%) showed blood stained mucous. However in both groups there were no other complications recorded.

By correlating the body weight of the patients to the laryngeal view grades; the study found that with increase body weight the incidence of high laryngeal view grade was also increased. This correlation was strongly significant ($p < 0.05$) Fig. 2.

After correlation of the body weight with the time of insertion of the endotracheal tube through the AIRQ into the trachea, it showed that the higher the body weight, the longer time for intubation of the patient. This correlation was statistically significant ($p < 0.01$) Fig. 3.

But clinically, this difference did not exceed few seconds and did not affect ventilation and oxygenation.

6. Discussion

The invention of AIRQ in the near last years had helped easy control of difficult airway together with increasing incidence of successful intubation. Many studies showed the efficiency of the device as ventilating as well as a conduit for endotracheal intubation. These studies also recorded any complications related to the use of the AIRQ [11]. The AIRQ allows the insertion of different tube sizes up to 8.5 mm ID comparing with classic LMA that allows maximally the insertion of 7 mm ID tubes. The supraglottic devices are now used in emergency medicine to secure airway [12].

After the induction of anesthesia and adequate muscle relaxation, the AIRQ 3.5 was easily inserted in all patients of the group from the first time compared with the group 4.5; the AIRQ was inserted from the second time in 2 patients of the group. The repeated trial of insertion was due to unfitting of the AIRQ on the laryngeal opening and inadequate ventilation of the patients. The difference was statistically and clinically significant among the groups [13–15].

The seal pressure values in the study are consistent with other studies on different supraglottic devices [16]. The fiberoptic bronchoscope was introduced to evaluate the laryngeal view grade followed by intubation of the patients. For group 3.5, grade 1 was recorded in 22 patients compared with 16 patients in group 4.5, while grade 5 was recorded in only 1(3.3%) patients of group 3.5 compared with 3(10%) patients in group 4.5.

The study found that in some patients, the greater the body weight, the higher the laryngeal view grade. By clinical
practice, the AIRQ 4.5 does not fit properly in a small percentage of patients compared to AIRQ 3.5 and this needs more manipulation to improve laryngeal view for intubation. The increased incidence of higher laryngeal view grades in obese patients is also consistent with the increased incidence of the long epiglottis, snoring and sleep apnea syndrome with obesity [17–21].

Also by correlating the body weight to the time of intubation we found that with increasing body weight the time of endotracheal intubation is also increased. This finding may be secondary to the higher laryngeal grade.

The study showed that the leak pressure in all patients was $24 \pm 1.7 \text{ cm H}_2\text{O}$ which is also consistent with previous studies [22,23]. All patients were easily and properly ventilated after insertion of the AIRQ, which was confirmed with ETCO2 waveform, chest expansion, chest auscultation and the absence of air leak from the mouth opening.

The insertion of the AIRQ 3.5 is easier than 4.5. This may be due to the large cup of the AIRQ 4.5. Our study showed that the time of insertion of the tube is increased with increasing body weight, and this may be explained by the increased incidence of higher laryngeal grade, manipulation to improve the view grade and the more time needed to bypass and “dive”

![Figure 2](image-url)

**Figure 2**  Correlation between laryngeal grade (lary_view_grade) and body weight (body_weight in kg). The more the body weight, the higher the laryngeal view grade ($P < 0.05$).

### Table 2  Demographic and descriptive statistics.

<table>
<thead>
<tr>
<th></th>
<th>All patients ($n = 60$)</th>
<th>Group 3.5 ($n = 30$)</th>
<th>Group 4.5 ($n = 30$)</th>
<th>$P$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (y)</strong></td>
<td>37.3 ± 12.2</td>
<td>34.7 ± 13.7</td>
<td>39.8 ± 10</td>
<td></td>
</tr>
<tr>
<td><strong>Sex, f:m</strong></td>
<td>22:38</td>
<td>14:16</td>
<td>8:22</td>
<td></td>
</tr>
<tr>
<td><strong>f n(%)</strong></td>
<td>22(36.7%)</td>
<td>14(46.7%)</td>
<td>8(26.7%)</td>
<td></td>
</tr>
<tr>
<td><strong>m n(%)</strong></td>
<td>38(63.3%)</td>
<td>16(53.3%)</td>
<td>22(73.3%)</td>
<td></td>
</tr>
<tr>
<td><strong>Weight (kg)</strong></td>
<td>77 ± 12.5</td>
<td>67 ± 5.4</td>
<td>87.2 ± 8.5</td>
<td>$&lt; 0.01^p$</td>
</tr>
<tr>
<td><strong>AWS</strong></td>
<td>1.65 ± 1.48</td>
<td>1.3 ± 1.4</td>
<td>1.9 ± 1.5</td>
<td>(0.01)*</td>
</tr>
<tr>
<td><strong>0</strong></td>
<td>21(35%)</td>
<td>13(43.3%)</td>
<td>8(26.7%)</td>
<td></td>
</tr>
<tr>
<td><strong>1</strong></td>
<td>7(11.7%)</td>
<td>3(10%)</td>
<td>4(13%)</td>
<td></td>
</tr>
<tr>
<td><strong>2</strong></td>
<td>13(21.7%)</td>
<td>8(26.7%)</td>
<td>5(16.7%)</td>
<td></td>
</tr>
<tr>
<td><strong>3</strong></td>
<td>10(16.7%)</td>
<td>3(10%)</td>
<td>7(23.3%)</td>
<td></td>
</tr>
<tr>
<td><strong>4</strong></td>
<td>9(15%)</td>
<td>3(10%)</td>
<td>6(20%)</td>
<td></td>
</tr>
<tr>
<td><strong>AIR Q attempts</strong></td>
<td>1 ± 0.2</td>
<td>1 ± 0</td>
<td>1.07 ± 0.2</td>
<td></td>
</tr>
<tr>
<td><strong>1st</strong></td>
<td>58(93.3%)</td>
<td>30(100%)</td>
<td>28(93.3%)</td>
<td></td>
</tr>
<tr>
<td><strong>2nd</strong></td>
<td>2(6.7%)</td>
<td>0(0%)</td>
<td>2(6.7%)</td>
<td></td>
</tr>
<tr>
<td><strong>Leak pre cm H_2O</strong></td>
<td>24.3 ± 1.8</td>
<td>24.2 ± 2</td>
<td>24.4 ± 1.8</td>
<td></td>
</tr>
<tr>
<td><strong>Laryngeal v. grade</strong></td>
<td>1.8 ± 1.3</td>
<td>1.5 ± 1</td>
<td>2.13 ± 1.4</td>
<td>$&lt; 0.01^p$</td>
</tr>
<tr>
<td><strong>Grade 1</strong></td>
<td>38(63.3%)</td>
<td>22(73.3%)</td>
<td>16(53.3%)</td>
<td></td>
</tr>
<tr>
<td><strong>Grade 2</strong></td>
<td>8(13.3%)</td>
<td>4(13.3%)</td>
<td>4(13.3%)</td>
<td></td>
</tr>
<tr>
<td><strong>Grade 3</strong></td>
<td>5(8.3%)</td>
<td>2(6.7%)</td>
<td>3(10%)</td>
<td></td>
</tr>
<tr>
<td><strong>Grade 4</strong></td>
<td>5(8.3%)</td>
<td>1(3.3%)</td>
<td>4(13.3%)</td>
<td></td>
</tr>
<tr>
<td><strong>Grade 5</strong></td>
<td>4(6.7%)</td>
<td>1(3.3%)</td>
<td>3(10%)</td>
<td></td>
</tr>
<tr>
<td><strong>ETT Atmp</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>1st</strong></td>
<td>58(96.7%)</td>
<td>28(93.3%)</td>
<td>30(100%)</td>
<td></td>
</tr>
<tr>
<td><strong>2nd</strong></td>
<td>2(3.3%)</td>
<td>2(6.7%)</td>
<td>0(100%)</td>
<td></td>
</tr>
<tr>
<td><strong>ETT insertime (s)</strong></td>
<td>20.1 ± 5.4</td>
<td>19.7 ± 3.8</td>
<td>22.2 ± 6.4</td>
<td></td>
</tr>
<tr>
<td><strong>AIR Q rmv time (s)</strong></td>
<td>20.7 ± 3</td>
<td>21 ± 2.7</td>
<td>20.3 ± 3</td>
<td></td>
</tr>
<tr>
<td><strong>Complications</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Laryngospasm</strong></td>
<td>1/60</td>
<td>0</td>
<td>1/30</td>
<td></td>
</tr>
<tr>
<td><strong>Laryngeal oedema</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Blood stained mucous</strong></td>
<td>1(3.3%)</td>
<td>0</td>
<td>1(3.3%)</td>
<td></td>
</tr>
<tr>
<td><strong>Aspiration</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hypoxemia</strong></td>
<td></td>
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</tbody>
</table>

Data are presented as mean ± SD. Frequencies are presented as number (%). $P < 0.05$ is considered significant v: view, atmp: attempt, inser: insertion, rmv: removal, s: seconds, pre: pressure, y: years, n: number.
under the epiglottis to find the way to the larynx. However no previous studies have been done to oppose or support our findings, so we recommend further studies. We succeeded to intubate all patients without any desaturation or hypoxemia. From our results, the longest time till intubation is within the accepted range of apnea time and without recording any case of desaturation [10].

In contrast to this study, a previous study showed desaturation during endotracheal intubation through supraglottic devices in 6 of 34 cases [23].

Our study recorded the number of attempts of intubation. At the beginning of the study, 26.7% patients were intubated from the second time in group 3.5. This was due to inability to slide the tube through AIR-Q secondary to dryness of lubricating gel. So k-y gel “Jhonson and Jhonson” was used instead, producing better lubrication of the AIR-Q and the tube, and allowing easy sliding of the ETT through the AIRQ. However for group 4.5 all patients (100%) were intubated from the first time. This may be secondary to its wider internal diameter in relation to the used 7.5 mm ID ETT.

Similar study has been done on pediatrics and found that the higher laryngeal view grade was found in younger children with lower body weight. This finding was explained by the different anatomical considerations in children from adults [10].

From our study we concluded that there is a proportional relationship between the body weight, laryngeal view grade and time of endotracheal intubation.

The time of removal of the AIRQ over the stylet is (20.7 ± 3) s. During this period, the patients were apneic, but no case showed desaturation. The removal of the AIRQ may result in dislodgement of the tube with it. In the present study, this complication was not recorded [24].

After removal of the AIRQ, it was examined for any blood streaked secretions that may be present due to rough manipulation or injury to the oral mucosa. Only one patient of group 4.5 has blood streaked mucous over the removed AIR-Q. These findings were consistent with previous studies on different supraglottic devices [25].

Post operatively, there were no other complications recorded in both groups, and this was consistent with previous researches [26]. This can be explained by the amount of air injected in the AIR-Q cuff (15–20 ml) max compared with the classic LMA that may reach up to 40 ml and may result in oedema of the airway, ischemia to the mucosa, or laryngospasm [11,25]. On the contrary, another study showed the occurrence of coughing, laryngospasm, and bronchospasm secondary to airway activation, sore throat, and blood staining on removal of the device. These complications were present in only 4% of cases separately [23,27].

7. Conclusion and recommendations

1. The AIRQ 4.5 has a larger and wider cup, making its insertion little bit difficult and more traumatic compared to AIR-Q 3.5.
2. Not only the body weight that may determine the size of the AIRQ, but also the oral cavity's inner volume. Some obese patients may have a small oral cavity making it difficult to properly insert the AIRQ 4.5.
3. The international connector becomes loose after certain time of use. It must be tighter (recommendations to the manufacturer).
4. Improving the laryngeal view grades through the AIRQ may be done by different manipulations as cricoid pressure, right or left device rotation, slightly inwards and outwards movement to optimize the laryngeal view grade and improve ventilation.
5. The AIRQ is easy to use, whether as a supraglottic ventilating device to secure airway or as a conduit for intubation through it.

Figure 3  Correlation between body weight (in kg) and insertion time (s). The more the body weight, the more time for intubation ($P < 0.001$).
6. In obese patients, the best supraglottic device to ventilate them is the AIRQ as it ventilates the patients through the auxiliary hole present above the keyhole opening even with complete occlusion of the keyhole opening by the fold of epiglottis.

7. In laryngeal view grade >3 it is not advised to blindly intubate the patients as it may result in trauma to the airway but it is better to intubate the trachea under direct vision using fiberoptic bronchoscope, however blind intubation is not included in our research and further studies are recommended.

8. Adequate lubrication of the tube and AIRQ prior to use preferably by k–y gel Jhonson and Jhonson or lidocaine gel.

References


The air-Q as a conduit for fiberoptic aided tracheal intubation in adult patients undergoing cervical spine fixation: A prospective randomized study

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Abstract  The air-Q™ intubating laryngeal airway is a supraglottic airway device which was designed to allow adequate patient ventilation and reliable blind endotracheal tube intubation. Objectives: To investigate the efficacy of air-Q as a conduit for fiberoptic endotracheal intubation in adult patients with limited cervical spine mobility compared with fiberoptic-guided intubation alone. Design: Prospective randomized study. Patients: Sixty adult (12 female) patients, ASA physical status I and II scheduled for cervical spine fixation under general anesthesia. Patients were randomized into two parallel groups. Exclusion criteria includes, history of difficult airway, mouth opening <3 cm, Mallampati class ≥III and, increased risk of aspiration of gastric contents. Intervention: In the first group, endotracheal intubation was aided with the fiberoptic scope while patients in the second group were intubated with the fiberoptic scope guided with the air-Q as a conduit. The number of attempts and time to successful insertion of air-Q and endotracheal tube were recorded. The fiberoptic quality of the vocal cords view as seen through the air-Q and ease of endotracheal tube insertion were also assessed.

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1. Introduction

Difficult airway should always be considered in patients presenting for surgery of the cervical spine. Thorough preoperative patient assessment should be performed, including previous history of difficult intubation, restricted neck mobility and stability of cervical spine. The decision must be reached after preoperative assessment whether to intubate the patient awake or asleep, and whether to intubate with or without the fiberoptic bronchoscope. Endotracheal intubation using direct laryngoscopy with manual in-line stabilization or a hard collar is acceptable for many patients provided that it can be performed without detrimental neck movement. The intubating laryngeal mask airway is a good alternative for intubation in these patients, with or without the aid of fiberoptic bronchoscopy [1].

The development of laryngeal mask airway LMA Fastrach and LMA-CTrach have facilitated LMA-aided tracheal intubation. The main advantages of LMA-assisted tracheal intubation include: easy insertion, better alignment of the glottis opening, and continuous patient oxygenation and ventilation. The air-Q™ Intubating Laryngeal Airway (ILA) is a new supraglottic airway device (available in different sizes, including pediatric sizes), which was designed to allow adequate patient ventilation and blind endotracheal intubation [2].

Advantages of the air-Q ILA over the classic laryngeal mask airway include: shorter, more curved and wider shaft which facilitates the insertion of cuffed endotracheal tube, easy removal of the airway adaptor, and availability of the option of removal of the laryngeal airway after tracheal intubation [3].

The air-Q Intubating Laryngeal Airway (ILA) is a useful device for intubation which can be used as a conduit for tracheal intubation with or without fiberoptic guidance in patients undergoing spine surgery with limited neck mobility. The efficiency of the Air-Q ILA for difficult airway management in adult patients has not been established.

The objective of this prospective study was to determine the efficacy of the air-Q ILA as a conduit for the fiberoptic scope for tracheal intubation in patients with limited cervical mobility with respect to insertion success rate, time, fiberoptic view of the glottis opening, and intra- and post-operative complications.

2. Methods

After institutional Ethics Committee approval and obtaining written informed consent from each patient, this study was conducted in Kasr El Aini hospital, Cairo University, Egypt. The study was conducted from March, 2010 to April 2011. Sixty patients scheduled for cervical spine fixation under general anesthesia for cervical spine instability and fracture spine were enrolled in the study. Inclusion criteria were patient age 18–65 yr, ASA physical status I and II and, body mass index (BMI) ≤ 30 kg/m². Patients were excluded if they have a previous history of difficult airway, mouth opening < 3 cm, Mallampati class ≥ III and, patients with gastroesophageal reflux disease (GERD) or other causes of increased risk of aspiration of gastric contents. Patients were randomized into two equal groups of 30 patients each using a sealed envelope technique. In the first group, tracheal intubation was aided with the fiberoptic bronchoscope alone (Group F), and in the second group tracheal intubation was facilitated using the air-Q as a conduit for the fiberoptic bronchoscope (Group A).

Upon arrival to the operating room standard monitors were applied, including noninvasive arterial blood pressure, electrocardiography and pulse oximetry monitoring (General electric, Solar 8000 M. Tram. Rac 4A). Patients were wearing a Philadelphia collar (Micromedex), which was kept on during the intubation. An i.v. cannula 16G was placed in a peripheral vein under local infiltration anesthetic, i.e. atropine 400 μg was given to the patient before induction of anesthesia.

After 3 min of preoxygenation, induction of anesthesia was achieved with fentanyl 2 μg/kg and propofol 2 mg/kg. After confirmation of adequate face mask ventilation, atracurium 0.5 mg/kg was given to facilitate endotracheal intubation. Patients were ventilated via a facemask with 100% oxygen until neuromuscular monitoring revealed absent response to a train-of-four stimulus.

In the first group (Group F), a fiberoptic bronchoscope (Karl Storz. Endoskope. Intubation fiberscope 5.2 x 65. Ref. 11301BN1), was adequately lubricated, and loaded with a cuffed endotracheal tube (ETT) (7 mm inner diameter in females and 8 mm in males) and inserted through the patient mouth. Jaw thrust, tongue pull by an assistant and gentle manipulation of the scope were allowed to facilitate visualization of the glottic opening. Once visualizing the carina the tube was passed into the trachea.

Successful tracheal intubation was confirmed with end-tidal carbon dioxide and auscultation of the patient’s chest. The time to successful intubation was measured in seconds (using a digital timer) from placement of the bronchoscope into the patient’s mouth until capnographic confirmation of correct placement of the ETT.

In the second group (Group A), an air-Q ILA (Cookgas LLC, Mercury Medical, Clearwater, FL) (reusable version, size 3.5–4.5 according to the patient’s weight) was inserted in patient’s mouth with the aid of a tongue depressor or jaw thrust maneuver then the ILA cuff was inflated following the manufacturer’s instructions. Successful insertion of the ILA

Results: The air-Q was easily inserted in all patients of the second group with mean insertion time (22.6 ± 4.3 s). The air-Q provided a good fiberoptic view of the vocal cords and successful tracheal intubation in 29 (96.7%) patients of the second group on the first attempt. Time to tracheal intubation in the second group was significantly shorter than the first group (21.6 ± 5.7 and 29.8 ± 6.2 s respectively). The air-Q was easily removed without any complications.

Conclusions: The air-Q as a conduit for fiberoptic scope provided a better view of the vocal cords and, less insertion time of the endotracheal compared to fiberoptic-aided endotracheal intubation in adult patients with limited cervical spine mobility scheduled for cervical spine fixation.
was confirmed by observing adequate bilateral chest inflation and square wave end-tidal capnogram with positive pressure ventilation. Time to successful insertion of the air-Q ILA was measured in seconds from touching the patient’s mouth with the device until capnographic confirmation.

A fiberoptic bronchoscope (the same model used in group I), loaded with a cuffed endotracheal tube, was introduced through the air-Q ILA lumen after removal of the connector. Once the carina was visualized the tube was passed through the air-Q ILA into the patient’s trachea. Successful tracheal intubation was confirmed with end-tidal carbon dioxide and auscultation of the patient’s chest. Time to successful intubation was measured in seconds from advancing the fiberoptic scope into the ILA until capnographic confirmation of intubation. After intubation the ILA cuff was deflated, and with the aid of the manufacturer’s removal stylet the ILA was removed, connecting the patient to the anesthesia circuit again and observing the end-tidal carbon dioxide.

In either group, insertion of the air-Q ILA or fiberoptic-aided tracheal intubation was considered a failure after 2 unsuccessful attempts.

Maintenance of anesthesia was achieved with oxygen 50% and air, sevoflurane, and intermittent boluses of intravenous fentanyl as needed. Atracurium infusion was adjusted to maintain adequate muscle relaxation as monitored with the nerve stimulator. During maintenance of anesthesia mean arterial blood pressure (MAP), oxygen saturation (SpO2), heart rate (HR), end-tidal CO2 concentration were continuously monitored.

At the end of surgery atracurium infusion was stopped and reversal of muscle relaxant was achieved with i.v. neostigmine 0.04 mg/kg and atropine in a dose of 0.01 mg/kg. Patients were extubated and transferred to the recovery area and assessed for any adverse events.

3. Measurements

The quality of fiberoptic view (as seen through the air-Q) was assessed and classified as grade I – full view of the vocal cord, II – partial view of the vocal cords including arytenoids, III – epiglottis only, IV – other (ILA cuff, pharynx, others) [4]. Number of attempts and, time to successful insertion of the ILA and ETT were recorded.

The ease of tracheal intubation was also assessed and graded as: grade I – easy intubation, II – mild difficulty, III – moderate difficulty, IV – failure of fiberoptic intubation.

Complications as oxygen desaturation (SpO2 < 92%), tracheal tube dislodgment during removal of the ILA, upper airway trauma (as evident by blood staining of the ILA, and sore throat) in the first postoperative hour, were also recorded.

4. Statistical analysis

Assuming that a difference of 20% or more in the intubation time between the two groups would be of clinical interest a sample size of 30 patients per group was calculated to achieve a power of 80% and a significance level of 0.05.

Data were analysed using Prism 5.0a (GraphPad Software, Inc.). Data were expressed as mean (± SD), ratio or percent as indicated. Comparison between groups was performed using unpaired t test. Categorical variables were compared using contingency tables and Fisher’s exact test. A P value of < 0.05 was considered statistically significant.

5. Results

The study included 60 patients (48 males and 12 females) scheduled for cervical spine fixation under general anesthesia, their mean age was (48.05 ± 5.166) yr and BMI was (26.85 ± 2.74) Kg/m2. Patients were divided into two equal groups.

Demographic data and clinical characteristics of patients are summarized in Table 1.

Insertion of the air-Q ILA was easily achieved on the first attempt in all patients of the second group (Group A) with mean insertion time (22.6 ± 4.3) s.

Successful insertion of the ETT was achieved in 28 patients (93.3%) of the first group (Group F) on the first attempt, 2 patients (6.7%) required a second attempt for successful intubation. Mean time to successful intubation was (29.8 ± 6.2) s. Tracheal intubation was also successful in 29 (96.7%) patients of the second group (Group A) on the first attempt; one patient (3.3%) required a second attempt for intubation. The mean time to successful intubation was (21.6 ± 5.7) s, the insertion time was significantly shorter than group F (P = 0.0001) (Table 2).

Regarding the fiberoptic quality of the laryngeal view (as seen through the air-Q), full view of the vocal cords was recorded in 18 (60%) patients and partial view of the vocal cords was reported in 11 (36.7%) patients of the second group (Group A). On the other hand, grade III (view of the epiglottis only) was reported in one patient (3.3%) of that group. No patients had a grade IV view. (Fig. 1)

Endotracheal intubation was reported to be easy in 19 patients of the first group (Group F) in comparison to 27 patients of the second group (Group A). This difference was statistically significant. (Table 3)

The air-Q ILA was successfully removed after tracheal intubation in all patients of the second group without any incidence of tube dislodgment.

Oxygen desaturation (SpO2 < 92%) was not reported in any patient of both groups; the minimum oxygen saturation reached during the study was 94% in one patient of the first group (Group F) who required a second attempt to successful intubation. Postoperative sore throat was not also reported in any of the study patients. Only one instance of blood staining of the ILA was recorded.

6. Discussion

Endotracheal intubation of patients with cervical spine pathology or fractures has to be performed with care avoiding excessive flexion, extension or rotation of the spine. Wearing a Philadelphia collar is very effective in preventing movement of the cervical spine while intubating these patients. However, this collar may limit mouth opening, rendering laryngoscopy and intubation more difficult. The fiberoptic bronchoscope is the method of choice for tracheal intubation in these patients [5].

The air-Q ILA is a new supraglottic airway device available in adult and pediatric sizes, in both single-use and reusable versions, and can be used as a primary airway during maintenance of anesthesia as well as a conduit for blind and fiberoptic-assisted tracheal intubation [6]. This study evaluated
the air-Q ILA as a conduit for fiberoptic-aided tracheal intubation in patients with limited cervical mobility subjected to cervical spine fixation under general anesthesia.

The insertion attempts of the air-Q ILA were limited to two attempts in our study in order to avoid undue trauma to the pharyngeal and laryngeal structures.

In the current study, the air-Q ILA was easily and successfully inserted with adequate patient ventilation in all patients of (Group A), and the insertion time was 22.6 ± 4.3 s. These results are in agreement with the obtained data by Joffe et al. [4] who reported a successful insertion time of 22 ± 14 s and successful insertion rate of 100% in 70 adult patients. They additionally evaluated the air-Q ILA as a primary airway in 57 of their patients. In another, earlier study, Bakker et al. [6] conducted a pilot study of the air-Q ILA in 59 patients, intubating 19 patients blindly through the ILA. They reported a mean ILA insertion time of 26 ± 13 s, and a success rate of ILA insertion of 100%. Comparing the insertion time and number of insertion attempts recorded in the current study with the reported time to successful insertion of the same device or other supraglottic airway devices, our results are in agreement with the previous results [7].

The air-Q ILA provided a superior view of the glottis opening during fiberoptic-aided tracheal intubation and this could be explained by that the device was designed to lift the epiglottis and improve airway alignment, increasing the success rate of blind endotracheal intubation. In the current study the air-Q ILA provided easy endotracheal intubation in 27 (90%) patients, and mild difficulty with intubation in 2 (6.7%) patients. These results

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Demographic data and clinical characteristics of patients (mean (SD)) or ratio.</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Group I (F) (n = 30)</td>
</tr>
<tr>
<td>Age (yr)</td>
<td>49.30 (5.402)</td>
</tr>
<tr>
<td>Gender (male/female)</td>
<td>23/7</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>77.67 (6.814)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>168.26 (5.362)</td>
</tr>
<tr>
<td>Body mass index (Kg/m²)</td>
<td>27.35 (2.319)</td>
</tr>
<tr>
<td>ASA I/II</td>
<td>17/13</td>
</tr>
</tbody>
</table>

ASA = American society of Anesthesiologists, P value < 0.05 was considered significant.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Number of attempts {n (%)} and time to successful insertion of Endotracheal tube {mean (SD)}.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group I (F) (n = 30)</td>
</tr>
<tr>
<td>ETT insertion attempts</td>
<td></td>
</tr>
<tr>
<td>First</td>
<td>28 (93.3%)</td>
</tr>
<tr>
<td>Second</td>
<td>2 (6.7%)</td>
</tr>
<tr>
<td>Fail</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Intubation time (S)</td>
<td>29.8 ± 6.2</td>
</tr>
</tbody>
</table>

*S = seconds, ETT (endotracheal tube), tube insertion was considered as failure after 2 attempts. P value < 0.05 was considered significant.

Figure 1  Fiberoptic quality of the vocal cord view (through the air-Q) Grade I – full view of the vocal cord, II – partial view of the vocal cords including arytenoids, III – epiglottis only, IV – other (ILA cuff, pharynx, others). Data are presented as percentage. Number of the patients in the group = 30 patients.

the air-Q ILA as a conduit for fiberoptic-aided tracheal intubation in patients with limited cervical mobility subjected to cervical spine fixation under general anesthesia.

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Ease of fiberoptic tracheal intubation {n (%)}</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Group I (F) (n = 30)</td>
</tr>
<tr>
<td>Easy intubation</td>
<td>19 (63.3%)</td>
</tr>
<tr>
<td>Mild difficulty</td>
<td>8 (26.7%)</td>
</tr>
<tr>
<td>Moderate difficulty</td>
<td>3 (10%)</td>
</tr>
<tr>
<td>Cannot intubate</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>

* P value < 0.05 was considered significant.

Statistically significant in relation to group I.
were in agreement with the results reported by Joffe et al. [4] who obtained adequate exposure of the vocal cords allowing intubation with minimal or slight resistance to passage of the endotracheal tube in 92% of their patients. In the current study, 2 patients in (Group F) required a second attempt to successful intubation. The difficulty to intubate these patients was due to excessive secretions obstructing the view of the cords in one patient, and in the other patient there was a difficulty to visualize the glottic opening due to large size epiglottis. Additionally, one patient in (Group A) needed a second attempt to intubate due to difficult threading of the tracheal tube.

Although previous studies have shown high success rate of blind tracheal intubation with the air-Q ILA within three attempts (60–74%) [6], we did not examine the air-Q ILA as conduit for blunt intubation as we preferred to use the bronchoscope to assist fiberoptic intubation in our patients with a potentially difficult airway.

As a conduit for fiberoptic-aided tracheal intubation, successful intubation was achieved in 29 patients of (Group A) on the first attempt and the insertion time was significantly lower than (Group F). Our results are in consistence with the reported results by Jagannathan et al. [8] who studied the use of the air-Q ILA as a conduit for ETT in 100 children. In their study, insertion of the ILA on the first attempt was successful in 99 children, and successful intubution in 97 of his patients on the first attempt and 3 patients on the second attempt with an average time of 24.8 ± 10.6 s.

Several methods for stabilizing the tracheal tube in place during removal of the air-Q after tracheal intubation were reported and include, the use of a second tracheal tube, laryngeal forceps, airway exchanger catheter, the removal stylet and a fiberoptic bronchoscope [9–12]. However, in the current study subsequent removal of air-Q after successful intubation was achieved in all patients of the second group using the removal stylet without tube dislodgement or oxygen desaturation in any of the patients.

Mucosal injury as recognized by the presence of blood on the air-Q ILA after removal was only recorded in one patient in the current study. Occurrence of sore throat was not observed during the current study. These results, being less than the incidence reported from other studies [4,6], may be explained by the fact that in our study, the air-Q ILA was promptly removed after successful intubation in all patients, as opposed to being used as the primary airway in the majority of the patients in these studies.

None of our patients reached SpO2 of < 92% at any point during intubation. The minimum oxygen saturation recorded in the current study was 94% in one patient in (Group F) due to failed first attempt at fiberoptic intubation, thereby prolonging intubation time. However, our study included only ASA I and II patients, thereby excluding patients with any significant pulmonary pathology. Had this study included a wider selection of patients, including those with pulmonary morbidity, there may have been a significantly higher rate and degree of desaturation during fiberoptic intubation attempt, demonstrating an advantage to using the air-Q as a conduit through which ventilation is possible.

7. Conclusion

In patients with limited (or undesirable) cervical spine mobility, the air-Q ILA appeared to be a safe and effective supraglottic airway device when used as a conduit for fiberoptic-aided tracheal intubation during cervical spine fixation. There was a significantly shorter insertion time of the ETT with the air-Q ILA used as a conduit compared to fiberoptic-aided tracheal intubation with no conduit. Intubation was achieved without significant airway trauma, and there was no dislodgement of the endotracheal tube during removal of the device.

Further studies with a larger number of patients with higher ASA scores and more difficult airway are needed to confirm the feasibility of using the air-Q as a conduit for tracheal intubation (either aided with the fiberoptic scope or blindly).

References

Recently, the Department of Burns and Plastic Surgery of Xi’an Central Hospital received a patient who suffered from scar contracture deformity of the neck having suffered burns, along with dysfunction.

Cicatrectomy and lysis on the neck under general anesthesia was planned to be performed on November 16. Preoperative airway assessment: severe chin-neck adhesion, head hypokinesis at 0 degrees, thyromental distance of 0, and mouth opening of 2 cm, this patient had a rare problematic airway. If the tracheal intubation failed and an unobstructed airway was not available, it would not be possible to perform the operation, with the patient’s life being threatened, and anesthesia was at high risk.

Before the operation, the Department of Anesthesiology discussed and prepared the optimum anesthesia protocol. The final decision was to use the new technology of a tracheal intubating laryngeal mask (Cookgas Intubating Laryngeal Airway, CILA) to solve the ventilation problem.

On November 16, at 08:00, after the patient entered the operating room, venous access was established and the patient was connected to the monitor. The operation was performed by Xiaogang Cui (Chief physician). First, a small amount of analgesic anaesthetic was given, and then a size 3.5 CILA was inserted via the mouth under autonomous respiration conditions.
When the appropriate position was confirmed, further anesthesia was administered and the operation proceeded as follows: the body of the fiber optic bronchoscope (FOB) was sheathed with a 6.5 mm ET tube; the ET tube was inserted into the trachea (the ET tube passed through the opening of the laryngeal mask airway via CILA and reached the glottis, then entered into the trachea via the glottis); the FOB was then removed; the patient was connected to a ventilator and the PETCO2 was monitored (showing successful tracheal intubation); the CILA was removed with the assistance of a dedicated CILA-removal stylet system; the ET tube was then fixed and successful anesthesia was achieved. When the operation was finished, the ET tube was removed. Post-operative follow-up suggested that the patient did not feel any discomfort.

Maintaining an unobstructed airway and performing tracheal intubation of the patient with severe chin-neck adhesion are often big challenges to the anesthetists. CILA is a new device, with the advantages of easy operation, high success rate of guiding intubation and so on. Furthermore, with the CILA an ordinary ET tube can be used directly to perform intubation. FOB-guided intubation technology is one of the most common and effective methods to solve the problem of difficult intubation at present. The combined application of the CILA and FOB-guided intubation technology not only solves ventilation problems in the management of difficult airways, but also improves the success rate of intubation in difficult airways. Such a combined application has the advantages such as easy operation, high success rate of intubation and minor cardiovascular response, providing a new solution for tracheal intubation in difficult airways.

Apparently such technology is only being applied in a few hospitals such as the teaching hospitals of The Fourth Military Medical University and Xi’an Jiaotong University, and this is the first time it was performed in a municipal hospital. The use of the new technology of CILA indicates that the Department of Anesthesia of our hospital has achieved a new level in managing difficult airways.

（麻醉科供稿）(By Department of Anesthesia)
Prospective evaluation of the self-pressurized air-Q intubating laryngeal airway in children

Narasimhan Jagannathan, Lisa E. Sohn, Ravinder Mankoo, Kenneth E. Langen, Andrew G. Roth & Steven C. Hall

Department of Pediatric Anesthesiology, Children’s Memorial Hospital, Northwestern University Feinberg School of Medicine, Chicago, IL, USA

Introduction

The air-Q™ ILA intubating laryngeal airway (ILA) (Cookgas LLC, Mercury Medical, Clearwater, FL, USA) has been designed for tracheal intubation and routine airway management during maintenance of anesthesia in both children and adults. A newer version of the ILA, the self-pressurized air-Q™ ILA (ILA-SP), has recently been introduced into our practice for routine airway maintenance in children. This supraglottic airway device shares structural similarities with the original ILA, including the ability to provide a reliable conduit for tracheal intubation (1,2). Two main features distinguish the ILA-SP from the original ILA: (i) the absence of a pilot balloon and (ii) continuity between the airway tube and the cuff through an inner aperture at their junction.

Keywords

children; airway devices; intubating laryngeal airway; laryngeal mask airway; air-Q

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Section Editor: Jerrold Lerman

Accepted 11 March 2011


Summary

Objectives: To assess the clinical efficacy of the self-pressurized air-Q ILA™ (ILA-SP).

Aim: The purpose of this prospective audit was to evaluate the feasibility of the ILA-SP in clinical practice and generate data for future comparison trials.

Background: The ILA-SP is a new first-generation supraglottic airway for children with a self-adjusting cuff and lack of a pilot balloon.

Methods: Over a 4-month period, 352 children with an ASA physical status of I–III, newborn to 18 years of age, undergoing various procedures were studied. Data points assessed included insertion success rates, airway leak pressures, quality of ventilation, and perioperative complications associated with the use of this device.

Results: In 349 of the 352 patients in this study, the ILA-SP was used successfully as a primary supraglottic airway device in a variety of patients. Three patients required conversion to a standard laryngeal mask airway or a tracheal tube. The mean initial airway leak pressure for all patients was 17.8 ± 5.4 cm H2O, and 20.4 ± 5.5 cm H2O when re-checked at 10 min, which was statistically significant (P < 0.001). Complications were limited to 14 patients and related to reflex activation of the airway (coughing, laryngospasm, and bronchospasm) (n = 10), sore throat (n = 3), and blood staining on removal of the device (n = 1). There were no episodes of regurgitation, aspiration, or hoarseness.

Conclusions: Acceptable clinical performance was demonstrated with the ILA-SP for a variety of procedures in infants and children with spontaneous and positive pressure ventilation. Future studies comparing this device to other supraglottic airways may provide useful information regarding the safety of the ILA-SP in pediatric clinical practice.
These features may allow for several clinical benefits when compared with other cuffed supraglottic airways: First, intra-cuff pressures are determined by the airway pressures, because of the equalization of pressures with the movement of gas between the cuff and airway tube. Second, lower intra-cuff pressures are maintained overall as a result of being limited by the peak airway pressures, with the highest pressures exerted during inspiration. Third, by not exceeding peak airway pressures, the balance between intra-cuff pressures and the airway seal of the device may be optimized at lower pressure. Therefore, the risk of sore throat, neuropraxic injury, and gastric insufflation seen with overinflation (3,4) of traditional cuffed supraglottic devices may be reduced. Figure 1 highlights the structural features of the ILA-SP.

The purpose of this study was to evaluate the clinical efficacy of this device assessing: (i) insertion success rates, (ii) airway leak pressures, (iii) quality of ventilation, and (iv) perioperative complications. The results obtained from this study will allow us to determine the feasibility of this device in clinical practice and generate data for future comparison trials.

Methods

This quality assurance study was approved by the IRB. The need for written parental consent was deemed unnecessary because the device was FDA approved and licensed for use in the USA. The ILA-SP was already in use in other pediatric institutions and a part of our standard practice for airway management with supraglottic airways and therefore not considered experimental. Over a 4-month period, 352 patients with an ASA physical status of I–III, newborn to 18 years of age, and scheduled to undergo an elective procedure requiring general anesthesia with a supraglottic airway device were consecutively included in this study. Exclusion criteria were ASA physical status ≥ IV, active respiratory tract infection (presence of rhinorrhea, cough, and temperature >38°C on the day of surgery), clinically significant pulmonary disease, severe gastrointestinal reflux, features or syndromes suggestive of a difficult airway, emergent surgery, or surgery requiring placement of a tracheal tube.

Four study investigators (NJ, LES, AGR, KEL) who were subspecialized in pediatric anesthesia performed all insertions of the ILA-SP in this study. Prior to this study, they were experienced in placing the original ILA in at least 25 pediatric patients.

After placement of standard monitors, we recorded the type of induction, size of ILA-SP inserted, and number of attempts required for successful insertion. Prior to insertion of the ILA-SP, adequate depth of anesthesia was confirmed by the lack of a motor response to jaw thrust (5). The ILA-SP was inserted using either a standard midline approach or a rotational method (6) depending on the study investigator’s preferred technique. A disposable ILA-SP was used in...
all patients; those weighing between 0 and 7 kg received a size 1.0 ILA, and 7 to 17 kg received a size 1.5 ILA, 17 and 30 kg received a size 2.0 ILA, and patients between 30 and 50 kg received a size 2.5 ILA, according to the manufacturer’s guidelines, while allowing for adjustments based on the study investigator’s clinical judgment. Guideline markings on the airway tube in relation to the patient’s upper gums/incisors were also used as a confirmatory measure for determining the appropriately sized ILA-SP (Figure 1). If resistance or difficulty with the insertion was encountered, an alternative method of insertion was allowed to achieve successful placement and considered a second attempt. If the airway leak pressures were not clinically acceptable, a change in size was permitted, and this event was also recorded as an additional attempt. Successful device placement and adequate ventilation was evidenced by bilateral chest excursion, tidal volumes of at least 7 ml·kg⁻¹, square-wave capnogram tracing with positive pressure ventilation, and the absence of an airway obstruction or dislodgement of the device. Once the ILA-SP was properly secured, the airway leak pressure was observed with the head in neutral position. The airway leak pressure was determined when an audible noise was heard over the patient’s mouth by closing the expiratory valve of the breathing circuit with a fresh gas flow of 3 l·min⁻¹ (7). The expiratory valve was immediately released when the leak pressure was determined by the onset of audible noise or if airway pressure reached 40 cm H₂O without an audible leak. A second airway leak pressure was taken at least 10 min later to observe whether there was a change in the airway seal. The mode of ventilation whether spontaneous, mechanical, or pressure support was noted and based on the study investigator’s preference. None of the patients in this study received neuromuscular blockade to facilitate mechanical ventilation. At the end of the procedure, the ILA-SP was removed under a deep plane of anesthesia in all patients. Standard institutional protocols were used to evaluate all patients postoperatively assessing the patients’ pain and sore throat.

Complications such as regurgitation of gastric contents, pulmonary aspiration, laryngospasm, bronchospasm, oxygen desaturation (SpO₂ < 90%), hoarseness of voice, blood on the ILA-SP after removal, or sore throat in children able to objectively report complaints (5 years and older) were also recorded. Failure of the ILA-SP in this study was defined as (i) the inability to achieve correct placement within three attempts, (ii) dislodgement of the device, (iii) inadequate ventilation as evidenced by obstructive chest wall movements, poor capnogram morphology, or an inability to achieve tidal volumes of at least 5 ml·kg⁻¹, or (iv) the need to convert to an alternative airway.

Previously, data on the original ILA size 1.5 and 2.0 described airway leak pressures to be 16.6 ± 5.5 cm H₂O (2). Our study was designed to detect a difference of 5 cm H₂O between the ILA-SP sizes. Assuming a similar variance in leak pressure with the ILA-SP and the original ILA, an alpha of 0.05, and a power of 90%, we calculated that a minimum of 26 patients would be required per group. Enrollment of eligible patients was performed continuously until this quantity was achieved in each group, recognizing this would lead to a greater number of patients being included in the cohorts of the ILA-SP sizes used most commonly.

Data were recorded intra-operatively using a standardized data collection sheet and analyzed using Microsoft Excel Spreadsheet and PASW Statistics 18 (SPSS Inc., Chicago, IL, USA). Data are expressed as mean ± sd. Statistical comparisons between the ILA-SP size cohorts were made using chi-square tests for categorical data, and ANOVA with Bonferroni’s multiple comparison tests for continuous data. A P value less than 0.05 was considered statistically significant.

Results

A total of 352 patients were included in this study. There were 221 male, and 131 female pediatric patients with a mean weight of 19.3 ± 11.2 kg and a mean age of 5.0 ± 4.0 years, who were divided into four cohorts according to the size of ILA-SP placed. Demographic information and the summary of results for all cohorts are presented in Table 1. Results for infants (under 10 kg) were also analyzed separately and are included in Table 2. Patients in this study underwent a variety of procedures: urological (n = 106), medical imaging (n = 83), general surgery (n = 49), orthopedic (n = 47), ophthalmological (n = 47), and otolaryngological (n = 20). Of the 352 patients studied, 298 received an inhalational induction with sevoflurane, six received an intravenous induction with propofol, and 48 received supplemental propofol after a sevoflurane induction.

The ILA-SP was inserted using the standard midline technique (n = 236) or rotational method (n = 115), with subsequent successful ventilation in 351 patients. In one patient, the ILA-SP could not be placed adequately, necessitating the conversion to a laryngeal mask airway (LMA) (LMA North America, San Diego, CA, USA). Placement of the ILA-SP was achieved on the first attempt in 336 patients, while 13 cases required a second attempt without a change in the insertion technique. Of the 13 needing a second
attempt, seven required a change in the ILA-SP size as determined by the study investigator. Upsizing of the ILA-SP occurred in six of the seven size changes owing to low airway leak pressures. Five of the six reports involved changing from size 1.5 to 2.0, and the other was from size 2.0 to 2.5. The one instance of ILA-SP downsizing was from size 2.0 to 1.5. The remaining six cases requiring a second placement attempt involved removal of the device secondary to increased resistance from light anesthesia upon initial placement followed by reinsertion of the same-size ILA-SP after increasing anesthetic depth. Three cases were recorded as failures: two required conversion to a tracheal tube because of laryngospasm and desaturation during maintenance of anesthesia and one required the use of a LMA size 2.0 because an adequate seal could not be achieved with the ILA-SP size 2.0 after two attempts.

The mean initial airway leak pressure for all patients was 17.8 ± 5.4 cm H₂O, and 20.4 ± 5.5 cm H₂O when re-checked at 10 min, and this difference was statistically significant (% < 0.001) (Figure 2). There were statistically significant differences in initial airway leak pressures between size 1.0 and 2.0 (% < 0.001), 1.5 and 2.5 (% = 0.004), and 2.0 and 2.5 (% < 0.001). At 10 min, there were statistically significant differences in airway leak pressures between size 1.0 and 2.0 (% = 0.031), 1.5 and 2.5 (% = 0.028), and 2.0 and 2.5 (% < 0.001). Spontaneous ventilation was reported in 203 patients, mechanical ventilation in 144, and 5 received pressure support ventilation. The mean peak airway pressures recorded were 15.28 ± 2.37 cm H₂O when positive pressure ventilation modes were utilized. Ventilation parameters were acceptable in all patients.

<table>
<thead>
<tr>
<th>Size</th>
<th>Weight recommendation (kg)</th>
<th>ILA 1.0</th>
<th>ILA 1.5</th>
<th>ILA 2.0</th>
<th>ILA 2.5</th>
<th>Total</th>
<th>Test/P-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>27</td>
<td>143</td>
<td>121</td>
<td>61</td>
<td>352</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>0.49 ± 0.61</td>
<td>2.1 ± 1.3</td>
<td>6.1 ± 2.3</td>
<td>11.2 ± 3.0</td>
<td>5.0 ± 4.0</td>
<td>ANOVA % &lt; 0.001</td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>6.3 ± 2.4</td>
<td>11.7 ± 2.3</td>
<td>21.2 ± 3.9</td>
<td>39.1 ± 8.4</td>
<td>19.3 ± 11.2</td>
<td>ANOVA % &lt; 0.001</td>
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<tr>
<td>Sex</td>
<td>Female</td>
<td>12</td>
<td>47</td>
<td>45</td>
<td>27</td>
<td>131 (37.2%)</td>
<td>Pearson χ² P = 0.383</td>
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<tr>
<td></td>
<td>Male</td>
<td>15</td>
<td>96</td>
<td>76</td>
<td>34</td>
<td>221 (62.8%)</td>
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<td>ASA physical status</td>
<td>1</td>
<td>13</td>
<td>91</td>
<td>68</td>
<td>38</td>
<td>210 (59.7%)</td>
<td>Pearson χ² P = 0.475</td>
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<td></td>
<td>2</td>
<td>10</td>
<td>32</td>
<td>38</td>
<td>13</td>
<td>93 (26.4%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>4</td>
<td>20</td>
<td>15</td>
<td>10</td>
<td>49 (13.9%)</td>
<td></td>
</tr>
<tr>
<td>Placement success</td>
<td>First attempt</td>
<td>24</td>
<td>141</td>
<td>112</td>
<td>59</td>
<td>336 (95.5%)</td>
<td>Unable to calculate χ² value. Frequencies are too small in ‘second attempt’ and ‘failed’ cells.</td>
</tr>
<tr>
<td></td>
<td>Second attempt</td>
<td>2</td>
<td>2</td>
<td>7</td>
<td>2</td>
<td>13</td>
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<tr>
<td></td>
<td>Failed</td>
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<td>0</td>
<td>2</td>
<td>0</td>
<td>3</td>
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<tr>
<td></td>
<td>Overall success</td>
<td>26</td>
<td>143</td>
<td>119</td>
<td>61</td>
<td>351 (99.7%)</td>
<td></td>
</tr>
<tr>
<td>Initial leak pressure (cm water)</td>
<td>19.9 ± 6.1</td>
<td>17.4 ± 5.1</td>
<td>16.8 ± 4.9</td>
<td>20.1 ± 5.9</td>
<td>17.8 ± 5.4</td>
<td>ANOVA % &lt; 0.001</td>
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</tr>
<tr>
<td></td>
<td>Leak at 10 min (cm water)</td>
<td>22.1 ± 6.7</td>
<td>20.3 ± 5.2</td>
<td>18.9 ± 5.1</td>
<td>22.7 ± 5.8</td>
<td>20.4 ± 5.5</td>
<td>ANOVA % &lt; 0.01</td>
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<tr>
<td>Adverse events</td>
<td>Airway complications</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(coughing, SpO₂ &lt; 90%, laryngospasm, bronchospasm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td>Mucosal trauma (blood-stained ILA, sore throat)</td>
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<td>0</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overall</td>
<td>1</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>14 (4.0%)</td>
<td></td>
</tr>
</tbody>
</table>

Data are presented as mean ± SD (range).
* % < 0.05 designates a statistically significant difference between cohorts; however, a clinical significance may not exist.
*

There were a total of three failed airways. In one patient, the ILA-SP could not be placed adequately necessitating the conversion to a laryngeal mask airway. In the two other patients, ILA-SP placement was successful; however, these were considered failures as tracheal intubation was required secondary to airway complications during maintenance of anesthesia.

Table 1 Demographic and descriptive statistics regarding use of the self-pressurized intubating laryngeal airway (ILA-SP)
A total of 14 complications were noted. Airway complications occurred in ten patients and involved laryngospasm without desaturation (n = 5), laryngospasm with desaturation (n = 2), bronchospasm without desaturation (n = 2), and bronchospasm with desaturation (n = 1). Of these, three were associated with the placement of the ILA-SP. In the remaining six patients, these events occurred either on induction or during the maintenance of anesthesia and were not related to the insertion of the device. Tracheal intubation was required in one patient for persistent desaturation from bronchospasm. In four patients, clinical evidence of potential mucosal trauma included sore throat (n = 3) and blood staining of the ILA-SP (n = 1). There were no cases of gastric regurgitation, aspiration, or hoarseness reported. A summary of airway-related complications and interventions is shown in Table 3.

**Discussion**

The concept of a self-pressurized cuff is new to supra-glottic airways. This simple design modification may have some clinical advantages. Insertion techniques are similar to other supraglottic airway devices but without the need for cuff manipulation. The pressure in the cuff is self-regulated and no longer a closed air space.

The success rates of insertion in this study were similar to those found in the literature on the use of traditional LMAs with reported first-attempt insertion rates of 90% (8,9), and overall insertion rates of 99–100% (8,10–14). Both the standard midline technique and the rotational method of insertion were found to be effective for the ILA-SP and may be a reflection of the study investigators’ prior experience with the device rather than the insertion technique itself. These results demonstrate an overall ease of placement on the first attempt, similar to reports on the original ILA (2) and LMA (8,9,13,15). Additionally, in infants, the ILA-SP may allow for a better anatomic fit when compared with the corresponding-size LMA. The wider mask bowl of the ILA-SP and its curved airway tube may improve approximation with oropharyngeal anatomy, providing greater lateral stability and better seating in the hypopharynx. This was evidenced by the lack of dislodgement or obstruction of the ILA-SP in infants.

In this study, the ranges of leak pressures are consistent with current evidence on the use of the original ILA (2) and LMA in children (8,11–13,16–18) Although there were statistically significant differences in airway leak pressures between both sizes 1 and 2.5 when compared with the size 2.0, it is likely to be clinically insignificant, as all patients were adequately ven-
tilated through the ILA-SP regardless of patient size and the mode of ventilation. In some LMA studies, airway leak pressures in infants were lower than in larger children (11,17,19) and raised concerns regarding the safety and effectiveness of positive pressure ventilation in smaller patients. In contrast, this study demonstrated airway leak pressures with the ILA-SP in infants that were comparable to those of the larger children. By increasing the range of pressures at which mechanical ventilation may be delivered, the ILA-SP may improve the applicability of supraglottic airway devices for the anesthetic management of smaller children. This may be of particular importance when dynamic changes in ventilatory pressures occur during surgical procedures. These findings require further study to evaluate the use of this device for positive pressure ventilation in infants.

An improvement in airway leak pressures was seen in the 10-min leak pressure testing, potentially indicating an improvement in airway seal across all cohorts. This may be secondary to the increased pliability of the cuff because of the warmth from body temperature and potential self-adjustment of the ILA-SP, with better alignment of the ventilating orifice to the laryngeal inlet. Additional studies are needed to verify this anatomic relationship. As a result of the ILA-SP design, airway seals may also have been optimized at lower intra-cuff pressures. This may be analogous to studies with the LMA showing an improvement in the mask seal when lower intra-cuff pressures are maintained (20,21).

Of the complications reported, the low rates of mucosal trauma in this study may be secondary to the increased pliability of the cuff because of the warmth from body temperature and potential self-adjustment of the ILA-SP, with better alignment of the ventilating orifice to the laryngeal inlet. Additional studies are needed to verify this anatomic relationship. As a result of the ILA-SP design, airway seals may also have been optimized at lower intra-cuff pressures. This may be analogous to studies with the LMA showing an improvement in the mask seal when lower intra-cuff pressures are maintained (20,21).

Of the complications reported, the low rates of mucosal trauma in this study may be secondary to the high first-attempt success rates and soft PVC material of the cuff and airway tube. Additionally, by eliminating the closed airspace in the cuff, the risk of overinflation is decreased, and the overall pressure exerted on the posterior pharyngeal wall and the risk for postoperative airway morbidities (3,22) are potentially minimized. This is of particular interest in the pediatric population where mucosal perfusion pressure is typically lower than in adults (21). Other complications were related to reflex activation of the airway (coughing, bronchospasm, laryngospasm), infrequent, promptly resolved with increased depth of anesthesia and/or bronchodilator therapy, and did not lead to patient morbidity. The overall complication rate in this study was lower (4%) when compared with larger LMA studies (11%) (8,15) and was limited to reflex activation of the airway and mucosal trauma. Some studies suggest that the smaller-sized LMAs, in particular sizes 1 and 1.5, may be associated with more frequent airway complications such as airway obstruction.
during maintenance in infants (8,15,19,23). The findings in this study did not indicate an increased complication rate in the smaller-sized ILA-SP’s when compared with the larger sizes. A larger number of patients are needed to provide more definitive conclusions in regard to the overall safety of this device in clinical practice.

There are several limitations to this study as a result of its observational nature and because validated clinical signs in our routine practice were used to assess the clinical efficacy of the ILA-SP. First, the induction and insertion techniques were not standardized. Second, a fiberoptic examination was not performed to determine the anatomic alignment of the ILA-SP in relation to the vocal cords. Third, there was no control with an established supraglottic device. Fourth, postoperative complications should be interpreted within the constraints that smaller children were not able to report subjective complaints such as a sore throat or may have been masked by postoperative pain medications. Fifth, our results may not be applicable to those who receive neuromuscular blockade. These limitations were inevitable because of the study design and thought to be acceptable for the purposes of this study.

The ILA-SP was inserted with a high degree of success on the first attempt. The airway leak pressures and ventilation parameters achieved for a variety of procedures were clinically acceptable throughout all patient sizes, even with the use of positive pressure ventilation. This study may serve as an initial assessment of the feasibility of the ILA-SP in clinical practice. Randomized comparison studies regarding this device are now needed to further assess the features of the ILA-SP in comparison with other supraglottic airway devices with traditionally designed cuffs for airway management in children.

**Acknowledgments**

The authors thank the manufacturer, Cookgas LLC, for their generous product support of the ILA-SP. The authors also thank the following colleagues for their support: Drs. PKB, CAH, AS, IIM, DOB, and PV.

**Conflict of interest**

None.

**Financial support**

The equipment used in this study was provided by generous product support by the manufacturer.

**Disclaimers**

The devices used in this study was provided by the manufacturer.

**References**

Self-pressurized intubating laryngeal airway in children

N. Jagannathan et al.

Anatomical relationships of the Air-Q supraglottic airway during elective MRI scan of brain and neck

Sir,

Recent resuscitation guidelines have been altered to prioritize chest compression over airway management and have strongly advocated the placement of a supraglottic airway (SGA) instead of an endotracheal tube (ETT) in cardiac arrest.1 The recent article by Segal et al.2 has suggested that supraglottic devices impedes cerebral blood flow by obstruction of the carotid arteries. We present a series of magnetic resonance images demonstrating the anatomic placement of an Air-Q SGA during routine anaesthesia.

A middle aged male presented for MRI of brain and spine related to cervical radiculopathy. Due to claustrophobia the study was performed under general anaesthetic with the placement of an Air-Q SGA with the cuff filled with gadolinium. Consent was obtained for the use of the images for management and teaching purposes. The Aurora Institutional Review Board considered this study exempt from IRB oversight.

Fig. 1 illustrates our findings. The vertical extent of the cuff of the SGA ranged from the inferior endplate of the second cervical vertebra to the level of the C6/7 intervertebral disc. The maximal horizontal width of the Air-Q was 6 cm at the level of the C4 vertebra. On review of all the available images, there appears to be no focal loss in calibre in the dimensions or in the shape of the common carotid artery and its major terminal branches.

The images also reveal asymmetry in placement of the cuff with the right cuff placed just lateral to the laryngeal inlet and medial to the attachment of the pharyngeal constrictors to the greater cornu of the hyoid. The left side of the SGA cuff lies lateral to the greater cornu of the hyoid and the pharyngeal constrictors have been distended laterally. Of note the carotid sheath lies posterolateral to the cuff at all times.

While we have shown that the Air-Q SGA does not cause significant anatomic distortion of the neck vasculature, it is important to note that this is no guarantee of adequate flow within the carotid arteries. Our patient was in a stable, anaesthetized condition and presumably pressure within the carotids was normal and unlikely to be compressed by the pressure generated by an SGA. This is very different from the work of Segal et al., which was a cardiac arrest model where pressure in the carotids was normal and unlikely to be compressed by the pressure generated by an SGA.

In our case it is clear that the carotids lie posterior and lateral to the cuff of the SGA. Given the positioning of the SGA it seems that the pressure of the cuff is directed anteriorly and laterally and is likely to have little direct pressure on the carotid sheath. This is in keeping with a previous cadaveric study, which showed anterior displacement of the laryngeal skeleton with inflation of the cuff of a SGA.3

The report by Segal et al., if applicable to humans, has significant implications for resuscitation guidelines. More work is needed to determine the effect of the SGAs in human subjects, both in healthy and critically ill subjects.
Conflict of interest statement

The authors declare that they have no conflicts of interest.

References


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THE ASA DIFFICULT AIRWAY ALGORITHM

From the 2014 USCD Anesthesiology Update, presented by the University of California, San Diego, School of Medicine, Department of Anesthesiology

Jonathan L. Benumof, MD, Professor of Anesthesiology, University of California, San Diego, School of Medicine, Department of Anesthesiology

Airway algorithm: preoperative airway evaluation first and best opportunity to avoid problems; important to recognize and prepare for problems; rescue options last opportunity to solve problems; American Society of Anesthesiologists (ASA) algorithm divided into 3 categories, or limbs; awake intubation after careful preoperative evaluation performed, anesthesia practitioner determines airway will be difficult; algorithm advises to guarantee and secure airway while patient awake; difficulties after general anesthesia (with or without paralysis)-airway determined not to be difficult after thorough evaluation, but patient develops problems after induction; algorithm advises on various options; inability to ventilate or intubate after general anesthesia-rescue option imperative to prevent patient death

Recognition of difficulty: algorithm begins with understanding or recognition of difficulty; lack of recognition may cause clinician to "freeze" and become unable to react mentally, physically, medically, or technically to resolve problem; high degree of suspicion enables adequate preparation and improves likelihood of resolving difficulties; ASA preoperative airway evaluation-11-step scheme; follows line of sight from upper incisors to larynx; requires careful focus of eyes and attention on each area

Teeth: upper incisors prevent laryngoscope blade from entering mouth in caudal direction; teeth press downward, or limit ability to lift up, proximal end of blade; ability to see corniculate cartilages (2 nodules at bottom of vocal cords, 2-3 mm in height) increases likelihood of successful intubation; ability to see any part of vocal cords above corniculate cartilages associated with excellent view of vocal cords; if corniculate cartilages cannot be seen, likelihood of ability to intubate markedly decreased; even 1 mm increase in length of upper incisors can limit view of corniculate cartilages (despite otherwise optimal positioning) because of unequal position of fucrum and decreased movement at distal end of laryngoscope; maxillary teeth in natural state overriding mandibular teeth-overflowing upper incisors prevent caudal direction of laryngoscope and force blade to enter mouth in cephalad direction, further limiting view of vocal cords; ability to move lower teeth (prognathism)-ability to perform this maneuver indicates temporal-mandibular joint likely has normal function (ability to move mandibular condyle across tubercle of temporal bone), meaning that lower jaw (and tongue) will move forward and laryngeal aperture will be wide; interincisor distance-patient must open mouth as wide as possible to measure; normal distance 5 to 6 cm (also indicates normal temporal mandibular joint); flange of Macintosh and Miller blades 2 cm deep, but blades also have certain radius of curvature; must have absolute minimum of 3 cm interincisor distance to place blade in mouth; small distance probably requires alternative to direct laryngoscopy

Pharynx: size of tongue-if tongue small in relationship to size of oropharyngeal cavity, easier to move it away and see pharyngeal structures; larger tongues hide structures and harder to manipulate; smaller tongue allows ability to view tonsils, tip of uvula, and faucets (entrance to posterior pharynx); as tongue enlarges relative to oropharyngeal cavity, and as it rises within cavity, obscures tonsils, then uvula and faucets; oropharyngeal Mallampati classification-determination of tongue size in relation to oropharyngeal volume, mostly in anterior-posterior direction; palate indicator of lateral volume; narrow, highly arced palate causes intubation difficulty because of lack of room for laryngoscope blade to lie beside tube within oropharynx; narrow area forces tube into line of sight under blade; relative anterior or posterior position of larynx in relationship to other upper airway structures-determined by length of mandibular space; obtained by measuring thyromental distance, because vocal cords directly under midpoint of thyroid cartilage; large space between inside of mentum and thyroid cartilage indicates straight line from upper incisors to larynx; smaller space indicates sharper curve and more difficulty viewing larynx; distance of <3 fingerbreadths (or < 6 cm) between inside of mentum and thyroid notch predicts difficulty; retrognathia-normal-sized jaw in posterior position, pushing tongue posteriorly; likely causes breathing difficulty, but not intubation difficulty; micrognathia-small jaw in normal anterior position; laryngeal complex moved anteriorly, causing sharp curve and difficulty with intubation (but no difficulty in breathing because tongue moved forward); not uncommon for both retrognathia and micrognathia to be present

Mandibular space: determine compliance-space occupied by tongue when laryngoscope blade lifted; compliant space will accept large tongue, but noncompliant space may not accept even small tongue; abscess, cancer, hematoma, infection/inflammation, laryngeal edema, and radiation increase fibrosis and decrease mandibular compliance

Educational Objectives

The goal of this program is to improve the management of the patient with a difficult airway. After hearing and assimilating this program, the clinician will be better able to:

1. Perform preoperative airway evaluation according to the American Society of Anesthesiologists algorithm for the difficult airway.
2. Integrate information from the examination to determine whether a patient is likely to have a difficult intubation.
3. Select appropriate patients for awake intubation.
4. Define an optimal attempt for laryngeal intubation and mask ventilation.
5. Perform rescue procedures when intubation attempts fail.

Faculty Disclosure

In adherence to ACCME Standards for Commercial Support, Audio Digest requires all faculty and members of the planning committee to disclose relevant financial relationships within the past 12 months that might create any personal conflicts of interest. Any identified conflicts were resolved to ensure that this educational activity promotes quality in healthcare and not a proprietary business or commercial interest. For this program, Dr. Benumof and the planning committee reported nothing to disclose.
periglottic pathology, subglottic devices (transnasal jet ventilation or surgical airway) required

**Questions and answers:** use of pharmacologic interventions, e.g., depolarizing vs nondepolarizing muscle relaxants—adequate relaxation needed for optimal attempt; 1 mg/kg of succinylcholine lasts from 7 to 9 min; cannot depend on patient returning to spontaneous ventilation to solve problem of inability to intubate or ventilate; clinician must resolve issue whether succinylcholine or nondepolarizing agent used; either type of muscle relaxant adequate if no contraindication; nondepolarizing agent must work quickly; speaker recommends 1.2 mg/kg of rocuronium (60-sec drug, succinylcholine 45-50 sec drug); succinylcholine problematic in patients with burns or upper motor neuron lesions; use of intubating laryngeal airway—speaker believes Cook gas best choice for LMA; all others present some difficulty of use; speaker feels Cook gas has best view.

**Acknowledgements**

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**Suggested Reading**

Research Article

Blind versus fiberoptic laryngoscopic intubation through air Q laryngeal mask airway

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KEYWORDS
Intubating laryngeal mask airway (LMA); Air-Q; Fiberoptic intubation

Abstract  Background: The practice of airway management has become more advanced in recent years. This advancement is demonstrated by the introduction of many new airway devices, several of which have been included in the American Society of Anesthesiology (ASA). The most recently developed is air-Q which has special features and benefits that make it characteristic.

The success rate of blind intubation versus fiberoptic intubation through air-Q was investigated in this study. Success rate and quality of fiberoptic guided intubations were assessed.

Method: This study was conducted on 80 patients who underwent urosurgical operations under general anesthesia. Patients were randomly allocated into two equal groups (\(n = 40\)); group I in which intubation was done blindly through air-Q, and group II in which intubation was done by FO through air-Q. All the patients were meticulously assessed by El Ganzouri score. Patients taking points from 0 to 4 were only allowed to be included in this study to avoid the use of the awake technique if the score was 5 or more. After induction of anesthesia patients were primarily ventilated with the air Q. Then the endotracheal tube was inserted either blindly or by FO through the air Q. Successful intubation was confirmed by chest wall movement, auscultation, and capnogram. After three trials of intubations the procedure was abandoned. Twenty-four hours post-intubation, patients were questioned on the occurrence of sore throat and hoarseness.

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1. Introduction

Classic laryngeal mask airway (LMA) has been the cornerstone in the management of difficult airway [1].

In 2005, Daniel Cookgas (St. Louis, MO, USA) has invented the new supraglottic device (air Q). It is used for efficient ventilation or endotracheal intubation and it was designed for smoother and easier insertion of the tube.

The air-Q was designed primarily to allow for the passage of conventional cuffed tracheal tubes when used for blind tracheal intubation [2].

The air Q intubating laryngeal airway (ILA) has undergone several refinements in design since its original introduction to the market. Importantly, the posterior portion or ‘heel’ of the cuff was enlarged based on post-market clinical experience indicating that air leaks were typically occurring between the posterior portion of the cuff and the base of the tongue [3].

The laryngeal mask air Q has special features and benefits which make it characteristic: Innovative tip design which prevents mask from folding, allowing a smarter insertion, an auxiliary hole that improves air flow and helps prevent epiglottic down-folding, an oval-shaped, hyper-curved airway tube which better approximates the anatomy for easy insertion, and a keyhole-shaped airway outlet to direct the ETT midline toward the laryngeal inlet facilitate intubation and mask ridges to improve anterior mask seal.

1.2. Anesthesia technique

After administration of 100% oxygen for 3 min, atropinization of the patient using 0.1 mg atropine, anesthesia was conducted using fentanyl 1–2 mg/kg followed by propofol 2 mg/kg and atracurium 0.5 mg/kg. The patient is mechanically ventilated using a face mask aided with inhalation anesthetic isoflurane until a full relaxation is established after about 3–5 min.

The air Q is held by the right hand, and a wooden tongue depressor is used by the left hand to facilitate introduction of the mask. Drive the mask by applying continuous pressure over the shaft until it stops. Flexion of the head may facilitate the application.

In another way tongue depression may be done using pressure of the left thumb. Tongue holding and jaw thrust may also be used.

The cuff of the air Q was inflated according to the manufacturer’s instructions. 5–10 cm³ of air is sufficient to inflate the cuff of the air Q. Our goal was to achieve a minimum leak (seal pressure or oropharyngeal leak pressure) of less than 40 cm H₂O. Leak pressures can be assessed by auscultation over the anterior neck and chest while observing the ventilator manometer during positive pressure ventilation. It can be measured by closing the expiratory valve of the circle system at a fixed gas flow of 3 l/min and noting the airway pressure.

2. Methods

This randomized controlled study was carried out in Kasr El Ainy Hospital. This study was conducted on 80 patients with ASA (I–II) who underwent uro surgical operations after the approval of institutional review board and obtaining the consent of the patients who were asked to receive general anesthesia. Patients were randomly assigned (by closed envelope) to two equal groups according to the used technique of endotracheal intubation as follows:

Group I: consisting of 40 patients who underwent blind endotracheal intubation using laryngeal mask air-Q.

Group II: consisting of 40 patients who underwent fiberoptic endotracheal intubation through air Q from the start.

Patients were meticulously assessed preoperatively by El Ganzouri score which includes seven criteria: Mallampati classification, body weight, head and neck movement, intercisor gap, Buck teeth, thyromental distance, and history of difficult intubation.

El Ganzouri scoring system was used according to those criteria to assess the expected difficulty of intubation [4].

2.1. Technique of insertion

2.1.1. Preparation of the air Q

Insertion of the proper size previously deflated and well lubricated endotracheal tube through the air Q to a depth of approximately 8–20 cm, depending on the air Q size. This will place the distal tip of the endotracheal tube at or just proximal to the opening of the air Q airway tube within the mask cavity. It is very important to lubricate the endotracheal tube and the air Q airway tube completely to ensure easy passage of the endotracheal through the air Q. The endotracheal connector must be removed and loosely reattached to its place, this will facilitate the removal during the application of the removal styllet.

The air Q balloon is deflated by suctioning the pilot balloon until two dimples on the under surface of the cuff appear.

2.1.2. Anesthesia technique

After administration of 100% oxygen for 3 min, atropinization of the patient using 0.1 mg atropine, anesthesia was conducted using fentanyl 1–2 mg/kg followed by propofol 2 mg/kg and atracurium 0.5 mg/kg. The patient is mechanically ventilated using a face mask aided with inhalation anesthetic isoflurane until a full relaxation is established after about 3–5 min.

The air Q is held by the right hand, and a wooden tongue depressor is used by the left hand to facilitate introduction of the mask. Drive the mask by applying continuous pressure over the shaft until it stops. Flexion of the head may facilitate the application.

In another way tongue depression may be done using pressure of the left thumb. Tongue holding and jaw thrust may also be used.

The cuff of the air Q was inflated according to the manufacturer’s instructions. 5–10 cm³ of air is sufficient to inflate the cuff of the air Q. Our goal was to achieve a minimum leak (seal pressure or oropharyngeal leak pressure) of less than 40 cm H₂O. Leak pressures can be assessed by auscultation over the anterior neck and chest while observing the ventilator manometer during positive pressure ventilation. It can be measured by closing the expiratory valve of the circle system at a fixed gas flow of 3 l/min and noting the airway pressure.

Results: The success rate in blind intubation was 70% while in FO intubation was 97.5%. and this difference was statistically significant (p < 0.05). The total time to intubate in seconds was longer in group I than in group II and this difference was statistically significant (p < 0.05).

Conclusion: In our patients the air Q appeared to be a safe supraglottic airway in general anesthesia with a low potential for trauma of the airway. It is used as a facilitator for blind intubation. It allowed successful blind intubation in 70% of the patients versus 97.5% using fiberoptic technique. Backed up by the presence of a flexible fiberscope, this device might be a useful alternative for the handling of difficult airway.

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Mechanical ventilation of about 10 ml/kg was established.

Time of insertion; is the time in seconds from touching the patients mouth with the air Q until capnographic confirmation.

2.1.3. Insertion of the ETT
For endotracheal intubation the ventilator is disconnected and the mask adaptor is also disconnected.

2.1.3.1. Blind tube insertion. It was tried aided by cricoid pressure until the tube passed into its place. The cuff of the tube was inflated and the cuff of the air Q was deflated. Then the tube is connected to the ventilator. Verification of tracheal intubation was done by capnogram. The depth of the tube was assessed either by auscultation or by fiberscope to ensure that its place is above the carina.

Scoring of the trial according to the time it lasts until capnographic confirmation is either score 2: time less than 50 s, score 1: time more than 50 s.

2.1.3.2. Fiber optic technique. Using a fiberoptic endoscope, pass the scope through the ETT and into the trachea under direct visualization using the scope as a guide. The scope was then removed and the ETT cuff was inflated and the tube connector was replaced, connection to the ventilator was established, and check for adequate ventilation was assessed.

2.1.4. Air Q removal procedure
Removing the air Q following the ETT intubation is easily accomplished with the aid of the air Q removal stylet. Three sizes are available. It consists of an adaptor connected to a rod. The adaptor is tapered from bottom to top to allow the stylet to accommodate multiple sizes of the ETT, and has horizontal ridges which engage the ETT in a firm secure grip for a good control of the user during the removal process and vertical grooves to facilitate the spontaneous breathing in spontaneously breathing patients.

2.2. Statistical methods
Data management and analysis were performed using SigmaStat program, version 3.5 (Systat Software Inc., USA). The graphs were done using Microsoft Excel 2007. The numerical data were statistically presented in terms of range, mean, standard deviation, median and interquartile range (IQR). Categorical data were summarized as percentages.

Comparisons between numerical variables of two groups were done by unpaired Student’s \( t \)-test for parametric data or Mann–Whitney Rank Sum test for non-parametric data. Comparing categorical variables were done by \( \chi^2 \)-test or Fisher exact test for small sample size. \( Z \)-test (at a confidence interval of 95%) was used for comparing single proportions.

All \( p \)-values were considered significant when \( p \)-values less than 0.05.

### Table 1
Comparison of the baseline demographic characteristics between group I and group II.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group I (( n = 40 ))</th>
<th>Group II (( n = 40 ))</th>
<th>( p )-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex distribution</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male [( n ) (%)]</td>
<td>29 (72.5%)</td>
<td>25 (62.5%)</td>
<td>0.474</td>
</tr>
<tr>
<td>Female [( n ) (%)]</td>
<td>11 (27.5%)</td>
<td>15 (37.5%)</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
<td>0.123</td>
</tr>
<tr>
<td>Range</td>
<td>20–66</td>
<td>18–70</td>
<td></td>
</tr>
<tr>
<td>Mean ± S.D.</td>
<td>44.400 ± 13.952</td>
<td>39.275 ± 15.381</td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
<td></td>
<td></td>
<td>0.145</td>
</tr>
<tr>
<td>Median (IQR)</td>
<td>76.0 (68.50–80.0)</td>
<td>70.0 (58.5–80.0)</td>
<td>0.145</td>
</tr>
</tbody>
</table>

### Table 2
Comparison of the frequency distribution to the airway score between group I and group II.

<table>
<thead>
<tr>
<th>Airway score</th>
<th>Group I (( n = 40 ))</th>
<th>Group II (( n = 40 ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2 (2.5%)</td>
<td>8 (20%)</td>
</tr>
<tr>
<td>1</td>
<td>8 (20%)</td>
<td>16 (40%)</td>
</tr>
<tr>
<td>2</td>
<td>20 (50%)</td>
<td>8 (20%)</td>
</tr>
<tr>
<td>3</td>
<td>8 (20%)</td>
<td>8 (20%)</td>
</tr>
<tr>
<td>4</td>
<td>2 (2.5%)</td>
<td>0 (0.0%)</td>
</tr>
</tbody>
</table>

### Table 3
Comparison of the characteristics between group I and group II.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group I (( n = 40 ))</th>
<th>Group II (( n = 40 ))</th>
<th>( p )-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airway score</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median (IQR)</td>
<td>2.0 (2.0–3.0)</td>
<td>1.0 (1.0–2.0)</td>
<td>0.007*</td>
</tr>
<tr>
<td>Insertion technique</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jaw thrust, tongue holding</td>
<td>25 (62.5%)</td>
<td>11 (27.5%)</td>
<td>0.003*</td>
</tr>
<tr>
<td>Jaw elevation</td>
<td>15 (37.5%)</td>
<td>29 (72.5%)</td>
<td></td>
</tr>
<tr>
<td>Total time to intubate (s)</td>
<td>Range 25–90</td>
<td>20–80</td>
<td>0.047*</td>
</tr>
<tr>
<td>Mean ± S.D.</td>
<td>55.375 19.228</td>
<td>47.250 16.678</td>
<td></td>
</tr>
</tbody>
</table>

* \( p \)-Value is significant if \(< 0.05 \).
3. Results

This study was conducted on total of 80 patients. The study group consisted of 54 (67.5%) males and 26 (32.5%) females; with a male to female ratio (2.1:1). Mean patient age was 44.087 ± 15.201 (range: 18–70 years) and mean patient weight 75.025 ± 13.956 (range: 50–120 kg) (Table 1).

There were no statistically significant differences in age, weight and gender characteristics of patients between the two groups \((p > 0.05)\) (Table 1).

Frequency distribution of the studied cases according to the airway score is showed in Table 2.

The median airway score of group I was statistically higher than that of group II, and difference was statistically significant \((p = 0.007)\) (Table 3).

As regards the insertion technique; insertion by jaw thrusting and tongue holding was more common in group I (62.5%), while jaw elevation was more common in group II (72.5%); this difference was statistically significant \((p = 0.003)\) (Table 3).

The total time to intubate in seconds was longer in group I than in group II and this difference was statistically significant \((p < 0.05)\) (Table 3 and Fig. 1).

In group I, 28 out of the total 40 patients (70%) had a successful intubation; where 22/28 (78.6%) were intubated in the first attempt but in one of them extraction during the removal of air Q occurred, three (10.7%) were intubated in two attempts and other three (10.7%) patients needed a 3rd attempt. 12/40 (30%) patients had failed the three attempts.

Regarding the total time to intubate in group I; 18/28 (64.3%) patients were intubated within less than 50 s (score 2) and 10/28 (35.7%) patients were intubated within more than 50 s (score 1) (Fig. 2).

In group II, 39/40 (97.5%) were successfully intubated; 34/40 (85%) were intubated successfully in the first attempt while five (12.5%) cases needed a second attempt that succeeded after deflation of the cuff or slight upward traction of the air Q in an attempt to visualize the glottis opening. The remaining one (2.5%) failed to be intubated in one of the three trials due to excessive secretions and blood resulted from multiple trials.

Regarding the total time to intubate in group II; 30/40 (75%) patients were intubated within less than 50 s (score 2) and 10/40 (25%) patients were intubated within more than 50 s (score 1).

The frequency distribution of successes and failures among group I was statistically significant from that of group II \((p = 0.002)\) (Table 4 and Fig. 2).

The number of attempts taken for intubation was statistically insignificant between the two groups \((p = 0.066)\) (Table 5).

The first time success rate using laryngeal mask air Q was 22/40 (55%); while with the fiberoptic it reached 34/40 (85%); and the difference was statistically significant \((p = 0.03)\) (Table 6).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group I ((n = 40))</th>
<th>Group II ((n = 40))</th>
<th>(p)-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Success</td>
<td>28 (70%)</td>
<td>39 (97.5%)</td>
<td>0.002*</td>
</tr>
<tr>
<td>Failure</td>
<td>12 (30%)</td>
<td>1 (2.5%)</td>
<td></td>
</tr>
</tbody>
</table>

\* \(p\)-Value is significant if <0.05.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group I ((n = 40))</th>
<th>Group II ((n = 40))</th>
<th>(p)-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st attempts success rate</td>
<td>22 (55%)</td>
<td>34 (85%)</td>
<td>0.027*</td>
</tr>
</tbody>
</table>

\* \(p\)-Value is significant if <0.05.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Successful attempts in group I ((n = 28))</th>
<th>Successful attempts in group II ((n = 39))</th>
<th>(p)-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of successful attempts ([n %(\text{%})])</td>
<td>22 (78.6%)</td>
<td>34 (87.2%)</td>
<td>0.066</td>
</tr>
<tr>
<td>2</td>
<td>3 (10.7%)</td>
<td>5 (12.8%)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3 (10.7%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
</tbody>
</table>
4. Discussion

Classic LMA is the most widely used supraglottic device all over the world and considered the cornerstone in the management of difficult airway, however, there are some limitations when it is used as a conduit for intubation.

The air-Q intubating laryngeal airway (Cookgas LLC, Mercury Medical, Clearwater, FL) is a new supraglottic airway device (Fig. 3).

The special features of air Q ILA makes it superior to the classic LMA; therefore, it has the potential to overcome the limitations of the classic LMA. The shaft of this airway is much shorter and curved, enough of proximal TT is still above the shaft, allowing for removal of the air Q without the aid of a stabilizing rod [5]. The more curved shaft prevents tube kinking, lack of grills in ventilatory orifice. The airway connector of the air Q ILA is easily removable eliminating this potential area where the pilot balloon of the TT can get stuck [6]. And, the most important is that intubation can be done with a standard normal size tube for age.

Air-Q fulfills the criteria of ideal supraglottic devices which are: ease of placement, reliable alignment of the glottis opening, ability to continuously oxygenate and ventilate, minimize disconnection time from the breath circuit.

There are, however, some limitations to the air Q ILA. It may not improve the view when it is used in conjunction with a flexible fiberscope in the presence of blood and secretions. Even in these situations, the alignment with the glottis anatomy may allow for increased success in the use of ‘light guided’ or blind techniques for intubation. The air Q ILA is of limited value in nasotracheal intubations and patients with no mouth opening [2].

Air Q is available in six sizes (1, 1.5, 2, 2.5, 3.5, 4.5) in disposable single use.

And in four sizes (2, 2.5, 3.5, 4.5) for reusable use.

When looking at complete airway management, the exit strategy can sometimes be just as important as airway placement. There are three sizes of the stabilizing rods.

The air Q offers us a removal stylet. The stylet stabilizes the previously inserted oral endotracheal tube and allows controlled removal of the air Q without dislodging the tube from the trachea.

The taper allows the stylet to accommodate standard endotracheal tubes in multiple sizes (4–8.5).

The ridges engage the endotracheal tube in a firm, secure grip, giving the user control of the endotracheal tube during removal.

The struts allow for a more secure grip on the stylet during the rotational movement of insertion.

Our study was the first to be done in Egypt using air-Q. This study was designed to discover the main differences in intubation using the blind or the fiberoptic technique through the new air Q LMA.

This study was conducted on a total of 80 patients. Our patients were randomly assigned to two equal groups according to the used technique of intubation as follows:

Group I: consisting of 40 patients who underwent blind endotracheal intubation using laryngeal mask air-Q.

Group II: consisting of 40 patients who underwent fiberoptic endotracheal intubation through air Q from the start.

The main findings in our study are that the success rate was 70% in group I compared to 97.5% in group II and this difference was statistically significant.

The total time to intubate in seconds was longer in group I (55.375 ± 19.228) than in group II (47.250 ± 16.678) and this difference was statistically significant ($p = 0.047^*$).

The overall failure rate within group I was 30%. The failure rate in group II was 2.5%. It was due to excess secretion, and the difference was statistically significant.

The success rate of intubation using fiberoptic is higher and less traumatic compared to blind intubation. With several trials of blind intubation the chance of success of following fiberoptic is limited due to excessive secretion.

The fate was known for 16 (40%) patients of group I where no complications were reported. Thirty-seven patients (92.5%) of group II had a non-complicated course. The data about the rest of the patients were not available.

Erlacher et al. also studied the air Q ILA as a facilitator for blind intubation. He found that the air Q appeared to be a safe supra glottic airway in general anesthesia with a low potential for traumatization. Used as a facilitator for blind intubation it allowed endotracheal intubation in 60% of the patients. Backed up by the presence of a flexible fiberscope this device might be a useful alternative for the handling of difficult airway [7].

The available studies are limited so further studies are needed to confirm our outcome and results.

As conclusion, air-Q is a new supraglottic device which can be used as an excellent ventilatory device as well as conduit for endotracheal intubation with the standard tube either blindly or by aid of fiberoptic.

This device can be used safely in the management of patients with difficult airway.
References


Elective use of supraglottic airway devices for primary airway management in children with difficult airways

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A difficult airway is characterized by an inability or difficulty in adequately establish bag mask ventilation and/or difficulty with conventional direct laryngoscopy.1 Since their introduction in the 1980s, supraglottic airways (SGAs) have an established role in both routine and emergent airway management of difficult airways in both adults and children.2–6 In the difficult airway population, SGAs can provide adequate oxygenation and ventilation, while simultaneously acting as a conduit for fibreoptic-guided tracheal intubation. Additional advantages include the ability to overcome upper airway obstruction7–12 and the possibility of maintaining the airway without the need for tracheal intubation.3,13 These benefits have resulted in adoption of SGAs as standard practice in many difficult airway guidelines for both adults6,14,15 and children.16,17 In the literature on the difficult airway, there are more reports on the use of SGAs as a conduit for tracheal intubation than on the use of SGAs alone as the primary means for airway management in both adults and children.1,8,9,17,18 In adults, it has been shown that SGAs can be successfully used as an alternative to tracheal intubation in the difficult airway, both electively, and for rescue of failed airways.1,18–24 However, there are only a few reports regarding SGA use for primary airway management in children with difficult airways. There is minimal evidence regarding the prolonged use of SGAs in children with known difficult airways, and is limited to isolated case reports on their use in a failed airway,25 and neonatal resuscitation.26,27 Given the minimal data regarding elective use of an SGA for primary airway management in the anticipated paediatric difficult airway, we sought to examine the effectiveness of this technique as an alternative to tracheal intubation. Therefore, the aim of this retrospective cohort study is to assess the success rates and adverse events related to the use of SGAs for primary airway management during anaesthesia in children with difficult airways.

Methods
After receiving approval from the Ann & Robert H. Lurie Children’s Hospital of Chicago Institutional Review Board, a
retrospective analysis of our institution’s electronic medical records was conducted. The inclusion criteria included all children between 1 day and 18 years of age with a difficult airway undergoing at least one surgical or medical procedure using an SGA for primary airway management during general anaesthesia, from 1 January 2009 to 1 January 2013. This period followed a practice change at this institution where use of an SGA for primary airway management became an alternative approach to tracheal intubation for some procedures in paediatric patients with a difficult airway.

**Patient selection**

All patients receiving general anaesthesia during this 48-month period were filtered by International Statistical Classification of Diseases and Related Health Problems (ICD)-9 codes on Epic (Epic Systems Corporation, Verona, WI, USA) using the following diagnoses associated with a difficult airway: Pierre Robin sequence, Treacher Collins, Hemifacial microsomia (Goldenhar syndrome), Sticklers syndrome, Mobius syndrome, Apert syndrome, Crouzon syndrome, Pfeiffer syndrome, Saethre–Chotzen syndrome, CHARGE syndrome (coloboma, heart defects, choanal atresia, growth retardation, genitourinary problems, and ear abnormalities), mucopolysaccharidosis (Hurler, Hunter, Sanfilipo, Morquio, Maroteaux–Lamy syndromes), Beckwith–Wiedemann syndrome, Freeman–Sheldon, Hallermann–Steiff, De Lange syndrome, tracheo/laryngomalacia, glottic web, subglottic stenosis, cystic hygroma, temporomandibular/cervical joint disease, and pharyngeal/laryngeal masses. These lesions were further classified into functional defects and include: supraglottic abnormalities (maxillary hypoplasia and mandibular hypoplasia), infiltrative diseases, chronic subglottic abnormalities, limited jaw, mouth, neck mobility, or all. A subsequent filter of ‘difficult airway’ as a keyword was then used to narrow the search further. Additionally, a second search strategy was conducted using the ‘difficult airway’ keyword without any other ICD-9 diagnosis to select for children with a history of difficult airway without an apparent aetiology. The electronic medical records of these final patients were then interrogated for an anaesthesia event using an SGA for primary airway management during their procedure.

The filter of difficult airway encompassed any patient with one or more of the above diagnoses with a description of difficult airway (difficult direct laryngoscopy defined as a documented Cormack and Lehane Grade of 3 or greater and the need for an alternate device for successful tracheal intubation (fibreoptic intubation, videolaryngoscopy, or both), difficult mask ventilation (defined as inadequate ventilation with the need for two-handed mask ventilation or impossible mask ventilation), or presence of both conditions. The exclusion criteria included any anaesthesia event where the trachea was primarily intubated using an SGA as a conduit for fibreoptic-guided tracheal intubation, and a description of isolated physical findings such as micrognathia or macrognathia in the chart without any other suggestion of a difficult airway. Successful use of the SGA was defined as use of the device to maintain anaesthesia without the need for replacement with an alternative airway (tracheal intubation or another SGA). In patients that received multiple anaesthetics, only the first anaesthetic was included in the study.

Patient characteristics such as age, sex, weight, height, ASA physical status, type of procedure, method of induction, type and size of SGA device placed, number of attempts for successful device placement, method of ventilation, success/failure associated with the device during anesthetic maintenance, or the need to intubate the trachea, complications (regurgitation, laryngospasm, bronchospasm, airway obstruction, and oxygen desaturations); and anaesthetic depth on removal of the SGA were also recorded.

All data were entered into Microsoft Excel 2010 (Redmond, WA, USA) and statistical analysis was performed using the statistical software SAS (SAS 9.3; SAS Institute). Data are expressed as mean [standard deviation (SD)]. Descriptive statistics were calculated on both continuous and categorical data. Descriptive statistics for continuous variables were calculated using mean (SD) through univariate analysis, and categorical variables were calculated using their frequencies, n (%).

**Results**

A total of 77,272 patients received general anaesthesia during a period of 4 yr in this free-standing paediatric hospital. Four hundred and fifty-nine patients were reported to have a difficult airway. Of those, 109 received ≥1 general anaesthetics using an SGA for primary airway management meeting the inclusion criteria for this study. Figure 1 represents a flow chart for children meeting the inclusion criteria.

The principal conditions associated with a difficult airway were craniofacial syndromes related to maxillary hypoplasia (n=11), mandibular hypoplasia (n=39), infiltrative diseases (n=16), chronic subglottic abnormalities (n=21), and limited jaw, mouth, neck mobility (n=8). Fourteen patients did not have any reported disorder related to a difficult airway and were classified as unanticipated difficult laryngoscopy (Table 1).

Patient characteristics are represented in Table 2. Of the 109 patients using an SGA for primary airway management, 69 had multiple anaesthetics with an SGA. The success rate of SGA use was 105/109 or 96%. In four patients, an alternative airway was needed; in two patients the SGA was replaced by another SGA type or size, and in the other two patients, the trachea was intubated using a fibreoptic bronchoscope through the SGA (Table 3).

Procedures requiring general anaesthesia were radiology (including computerized tomography (CT) scans, magnetic resonance imaging (MRI), and interventional radiology (IR) procedures), general surgery, medical procedures (including electromyography, auditory brain response testing, cardiac catheterization, and upper/lower gastrointestinal endoscopy), orthopaedic surgery, plastic surgery, urology, ophthalmology, and neurology. Table 4 represents the types of SGAs used and length and type of procedure. Mask induction was performed in 92 patients, of whom 13 also received additional i.v. agents. Seventeen patients underwent i.v. induction alone (Table 2). Spontaneous ventilation was utilized in all patients, with 43 patients requiring pressure support ventilation.
The SGAs used were: LMA Unique™ (Teleflex; Triangle Park, NC, USA): size 1 (n=1), size 1.5 (n=5), size 2 (n=33), size 2.5 (n=14), size 3 (n=14), and size 4 (n=2); air-Q™ (Mercury Medical Clearwater, FL, USA): size 1 (n=4), size 1.5 (n=16), size 2 (n=7), size 2.5 (n=6), size 3.5 (n=2), size 4.5 (n=1), and one case without documented size; and LMA Supreme™ (Teleflex): size 2 (n=2) and size 3 (n=1).

Oxygen desaturation (SpO₂ < 85%) during placement was documented in two patients. One patient had laryngospasm on inhalation induction which was successfully broken with continuous positive airway pressure, followed by successful use of the SGA. In the other patient, the SGA was removed at the conclusion of the procedure under a deep plane of anaesthesia, and the clinician was unable to adequately ventilate the lungs and immediate direct laryngoscopy was performed with a Grade IV laryngoscopic view. Subsequently, the air-Q™ was placed with successful fibreoptic-guided tracheal intubation. There were no episodes of regurgitation of gastric contents, bronchospasm, or death reported. Removal of the SGA was performed in the awake state in 42% (n=46) of the cases, and under a deep anaesthetic plane in 56% (n=61) of the cases.

Discussion
The main finding in this study is that in children with difficult airways, SGAs can be effectively utilized for airway maintenance for an extended period of time and for various medical and surgical procedures.

SGAs already have an established role in the management of difficult airways, and there are several reports on the use of SGAs (LMA and air-Q) for fibreoptic-guided tracheal intubation in the paediatric difficult airway population. We and others have previously reported on the effectiveness of SGAs for oxygenation and ventilation in the difficult airway population before fibreoptic-guided tracheal intubation. The results of this study further suggest that the airway can be maintained with the SGA alone without the need for tracheal intubation in cases where risk of pulmonary aspiration is low. Although some difficult airway algorithms suggest the use of these devices for primary airway maintenance if the trachea cannot be intubated, reports on the feasibility of using an SGA in this setting is limited in children.

The relatively high success rates of SGA use observed in this study could be attributed to the fact that children with difficult airways often have anatomic lesions affecting the face, jaw, tongue, mouth, upper airway, or all, with unlikely disease involving the lower airways. The successful use of the SGA in these children suggests that the device can bypass these anatomic defects to seat in the hypopharynx and maintain a patent airway during anaesthetic maintenance. It was not possible to definitely include all cases where the clinician might have opted not to attempt the use of an SGA because of anticipated

Assessed for eligibility (patients having general anesthesia Jan 2009 – Jan 2013; n=77,272)

Patients with difficult airway (n=459)

Patients undergoing the following were excluded from the study:
- Tracheal intubation via SGA (n=213)
- Tracheal intubation using fibreoptic bronchoscopy or videolaryngoscopy (n=19)
- No artificial airway needed (n=118)

Patients undergoing procedures utilizing SGAs as primary airway management (n=109)

Failure of SGA during procedure (n=4)

Successful use of SGA during procedure (n=105)

Replaced with tracheal tube (n=2)

Replaced with a different size SGA (n=2)
difficulty or failure of the device. Therefore, the unintentional exclusion of these patients might overestimate the efficacy of our results. For these reasons, the results in this study cannot be extrapolated to all children with difficult airways.

The practical utility of SGAs for primary airway management in the difficult airway population has several clinical implications: first, the SGA can be used as a ventilation and oxygenation conduit, and, if intraoperative conditions change, offers a relatively straightforward path to intubate the trachea. As a result, the clinician’s ‘Plan A’ (SGA alone for airway maintenance) and ‘Plan B’ (conversion to tracheal intubation through the SGA) is encompassed with one airway management strategy (as seen with two of the failures in this study). Secondly, during on-site general anaesthesics (i.e. CT, MRI, and IR), children with a difficult airway may need to have their trachea intubated in the operating theatre before being transported to an

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**Table 1** Functional classification of the difficult airway conditions in the study cohort (n = 109)

<table>
<thead>
<tr>
<th>Functional problem</th>
<th>Anatomic features</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supraglottic abnormalities</td>
<td>Maxillary hypoplasia:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Apert syndrome</td>
<td>8 (7.4)</td>
</tr>
<tr>
<td></td>
<td>Crouzon syndrome</td>
<td>1 (0.9)</td>
</tr>
<tr>
<td></td>
<td>Pfeiffer syndrome</td>
<td>1 (0.9)</td>
</tr>
<tr>
<td></td>
<td>Saethre–Chotzen syndrome</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>DiGeorge syndrome</td>
<td>1 (0.9)</td>
</tr>
<tr>
<td>Mandibular hypoplasia:</td>
<td>Pierre Robin sequence</td>
<td>8 (7.4)</td>
</tr>
<tr>
<td></td>
<td>Treacher Collins</td>
<td>3 (2.8)</td>
</tr>
<tr>
<td></td>
<td>Goldenhar syndrome</td>
<td>14 (12.8)</td>
</tr>
<tr>
<td></td>
<td>Stickers syndrome</td>
<td>1 (0.9)</td>
</tr>
<tr>
<td></td>
<td>Mobious syndrome</td>
<td>1 (0.9)</td>
</tr>
<tr>
<td></td>
<td>Micrognathia</td>
<td>10 (9.2)</td>
</tr>
<tr>
<td></td>
<td>CHARGE association</td>
<td>2 (1.8)</td>
</tr>
<tr>
<td>Infiltrative diseases</td>
<td>Mucopolysaccharidoses:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hurler syndrome</td>
<td>4 (3.7)</td>
</tr>
<tr>
<td></td>
<td>Hunter syndrome</td>
<td>3 (2.8)</td>
</tr>
<tr>
<td></td>
<td>Sanfilipo syndrome</td>
<td>1 (0.9)</td>
</tr>
<tr>
<td></td>
<td>Marquio syndrome</td>
<td>5 (4.6)</td>
</tr>
<tr>
<td></td>
<td>Maroteaux–Lamy syndrome</td>
<td>1 (0.9)</td>
</tr>
<tr>
<td></td>
<td>Other:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Beckwith–Wiedemann syndrome</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Sturge–Weber syndrome</td>
<td>2 (1.8)</td>
</tr>
<tr>
<td>Chronic subglottic abnormalities</td>
<td>Subglottic stenosis</td>
<td>8 (7.4)</td>
</tr>
<tr>
<td></td>
<td>Tracheal stenosis</td>
<td>3 (2.8)</td>
</tr>
<tr>
<td></td>
<td>Laryngo/tracheomalacia</td>
<td>7 (6.6)</td>
</tr>
<tr>
<td></td>
<td>Masses (neck/parapharyngeal)</td>
<td>3 (2.8)</td>
</tr>
<tr>
<td>Limited jaw, mouth neck mobility</td>
<td>Freeman–Sheldon syndrome</td>
<td>1 (0.9)</td>
</tr>
<tr>
<td></td>
<td>Noonan syndrome</td>
<td>1 (0.9)</td>
</tr>
<tr>
<td></td>
<td>Spinal fusion</td>
<td>1 (0.9)</td>
</tr>
<tr>
<td></td>
<td>Cervical stenosis</td>
<td>1 (0.9)</td>
</tr>
<tr>
<td></td>
<td>Cervical instability</td>
<td>2 (1.8)</td>
</tr>
<tr>
<td></td>
<td>Alagille syndrome</td>
<td>2 (1.8)</td>
</tr>
<tr>
<td>Unanticipated difficult airway</td>
<td>Difficult direct laryngoscopy</td>
<td>14 (12.9)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>109 (100)</td>
</tr>
</tbody>
</table>
Table 3  Cases of SGA failure during anaesthesia. FOI, fibreoptic intubation; SGA, supraglottic airway; CPAP, continuous positive airway pressure; MRI, magnetic resonance imaging

<table>
<thead>
<tr>
<th>Age (months)</th>
<th>Cause of difficult airway</th>
<th>SGA type</th>
<th>SGA size</th>
<th>Reason for replacing the SGA</th>
<th>Definitive airway device used for the procedure</th>
<th>Type of procedure</th>
<th>Complications</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Mandibular hypoplasia. History of difficult direct laryngoscopy needing FOI</td>
<td>LMA Unique™</td>
<td>2</td>
<td>Difficult placement of initial devices → SGA downsized</td>
<td>LMA Unique™ size 1</td>
<td>Transthoracic echocardiogram</td>
<td>Laryngospasm desaturation (lowest: ( \text{SpO}_2 ) of 40%)</td>
<td>Difficulty seating of LMA size 1.5 and air-Q™ size 1. Laryngospasm broken with CPAP, LMA size 1 then placed for remainder of case</td>
</tr>
<tr>
<td>126</td>
<td>Parapharyngeal Rhabdomyosarcoma</td>
<td>LMA Unique™</td>
<td>3</td>
<td>Large airway leak → SGA upsized</td>
<td>LMA Unique™ size 4</td>
<td>Venous port insertion</td>
<td>None</td>
<td>Large airway leak during procedure; LMA size 3 replaced by LMA size 4</td>
</tr>
<tr>
<td>11</td>
<td>Hurler syndrome</td>
<td>LMA Unique™flexible</td>
<td>2</td>
<td>Surgeon unable to position mouth gag → partial airway obstruction</td>
<td>Cuffed 4.0 tracheal tube</td>
<td>Bilateral ear irrigation/ MRI/adenoidectomy/ central line placement</td>
<td>None</td>
<td>Difficult direct laryngoscopy; Grade IV view. FOI through LMA Unique™ then performed successfully on first attempt</td>
</tr>
<tr>
<td>77</td>
<td>Hunter syndrome</td>
<td>Air-Q™</td>
<td>2.5</td>
<td>Desaturation/loss of end tidal ( \text{CO}_2 ) → complete airway obstruction</td>
<td>Cuffed 6.0 tracheal tube</td>
<td>Bilateral carpal tunnel release</td>
<td>Desaturation (lowest: ( \text{SpO}_2 ) of 94%)</td>
<td>Air-Q™ removed and replaced allowing marginal ventilation. Replaced by another air-Q™ size 2 with FOI through air-Q™, despite ongoing poor ventilation</td>
</tr>
</tbody>
</table>

Table 4  Time and type of procedure performed and type of successful use of SGA (n=105). ENT, ear, nose and throat; SD, standard deviation; SGA, supraglottic airway

<table>
<thead>
<tr>
<th>Type of procedure</th>
<th>Mean time in minutes (SD)</th>
<th>Type of SGA</th>
<th>LMA Unique™</th>
<th>Air-Q™</th>
<th>LMA Supreme™</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENT</td>
<td>12.3 (7.9)</td>
<td>12</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>General surgery</td>
<td>61.6 (34.7)</td>
<td>10</td>
<td>4</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Medical/minimal invasive</td>
<td>90.5 (27.3)</td>
<td>6</td>
<td>3</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Neurosurgery</td>
<td>32</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Ophthalmologic</td>
<td>14.1 (31.4)</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Orthopaedic</td>
<td>93 (34.2)</td>
<td>6</td>
<td>3</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Plastic</td>
<td>80 (36.6)</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Radiologic</td>
<td>76.2 (36.3)</td>
<td>29</td>
<td>16</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Urologic</td>
<td>97.7 (55.8)</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>86.2 (47.2)</td>
<td>66</td>
<td>36</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
off-site location, then subsequently transported back to the operating theatre for tracheal extubation. This process can be precarious, present scheduling challenges, and require additional resources and equipment. The use of an SGA in this setting can reduce the need to transport these patients. Thirdly, as children with a difficult airway often present for multiple procedures requiring general anaesthesia, the successful use of these devices in one anaesthetic might influence the decision to use an SGA for a subsequent general anaesthetic. Finally, SGAs offer a less invasive option when compared with tracheal intubation. In this study, the rates of complications were relatively low, even with its use in children with a known diagnosis of a difficult airway.

There are several limitations to this study: (i) the relative under- and over-reporting of patients inherent in a retrospective study design, including inconsistent documentation of anaesthesia records; (ii) the possibility that certain difficult airway lesions improved from the time of initial difficult airway documentation to the time the child underwent anaesthesia with an SGA; and (iii) the use of an SGA is a decision based on multiple factors including type/length of procedure and comfort level of the clinician. These confounding factors could have influenced our results and the decision to proceed with tracheal intubation vs using an SGA for some procedures.

In conclusion, SGAs can be an effective option for airway maintenance in the paediatric difficult airway population. Future prospective studies are now indicated to stratify the factors that might be associated with failure of an SGA and which type(s) of patients, procedures, and SGAs are best suited for children with difficult airways.

Authors’ contributions
N.J., L.S.-R., L.S. contributed to the conception and design of the study, data acquisition, analysis and interpretation of the data, drafting the article, and the final approval of the version to be published. A.S. and B.W. contributed to data acquisition, drafting the article, and the final approval of the published version. K.S. contributed to analysis and interpretation of the data, drafting the article, and approval of the final version to be published.

Declaration of interest
None declared.

Funding
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Evaluation of chest compression effect on airway management with air-Q®, aura-i®, i-gel®, and Fastrack® intubating supraglottic devices by novice physicians: a randomized crossover simulation study

Nobuyasu Komasawa · Ryusuke Ueki · Yoshiro Kaminoh · Shin-ichi Nishi

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Abstract

Purpose In the 2010 American Heart Association guidelines, supraglottic devices (SGDs) such as the laryngeal mask are proposed as an alternative to tracheal intubation for cardiopulmonary resuscitation. Some SGD can also serve as a men for tracheal intubation after successful ventilation. The purpose of this study was to evaluate the effect of chest compression on airway management with four intubating SGD: aura-i® (aura-i), air-Q® (air-Q), i-gel® (i-gel), and Fastrack® (Fastrack), during cardiopulmonary resuscitation using a manikin.

Methods Twenty novice physicians inserted the four intubating SGD into a manikin, with or without chest compression. Insertion time and successful ventilation rate were measured. For cases of successful ventilation, the blind tracheal intubation via the intubating SGD was performed, with chest compression and success or failure, within 30 s was recorded.

Results Chest compression did not decrease the ventilation success rate of the four intubating SGD (with chest compression: air-Q, 19/20; aura-i, 19/20; i-gel, 16/20; Fastrack, 10/18). Inertion time was significantly lengthened by chest compression in the i-gel trial (p < 0.05), but not with the other three devices. The blind intubation success rate with chest compression was the highest in the air-Q trial (air-Q, 15/19; aura-i, 14/19; i-gel, 12/16; Fastrack, 10/18).

Conclusions This simulation study revealed the utility of intubating SGD for airway management during chest compression.

Keywords aura-i • air-Q • i-gel • Fastrack • Chest compression • Manikin • Novice physician

Introduction

Securing the airway during cardiopulmonary resuscitation (CPR) is technically challenging and is influenced by the location and position of the patient and skills of the rescuer. The American Heart Association (AHA) 2010 guidelines suggest supraglottic devices (SGDs), such as the laryngeal mask (LMA), as alternatives to tracheal intubation during CPR [1, 2]. A number of reports suggest that SGD have advantages over ordinary tracheal intubation for airway management under emergency situations, such as cardiopulmonary arrest. However, tracheal intubation is preferred in situations such as tracheal ventilation during recovery of spontaneous circulation [2].

Several SGD have unique features that render them useful for difficult or emergency airway management [3, 4]. One such SGD is the intubating SGD, which allows tracheal...
intubation via the inner lumen (5, 6). Although several types of intubating SGD s are commercially available (7, 8), they have not been compared or evaluated for airway management during chest compression.

This study aimed to compare the performance of four intubating SGD s [air-Q® ("air-Q"); Cook Medical, USA), i-gel® ("i-gel"); InterSurgical, USA), Ambu Aura-i® ("aura-i"); Ambu, Denmark), and the single-use LMA Fastrack® ("Fastrack"; Laryngeal Mask, Prodol Medical, Spain)] for emergency airway management during chest compression. Our primary endpoint was the evaluation of these four intubating SGD s for successful ventilation with or without chest compression, and the secondary endpoint was the evaluation of blind intubation via the SGD s after successful ventilation.

Materials and methods

This study was approved by the Research Ethics Committee of Hyogo College of Medicine. Twenty-two novice physicians at Hyogo College of Medicine with less than 1 year of experience with anesthesia were targeted; 20 agreed to participate and provided written consent. We asked the doctors about their prior experience with general anesthesia and usage of the intubating SGD s.

The AirMan (Laerdal, Sentrum, Stavanger, Norway) was used as the manikin for chest compression, intubating SGD insertion, and intubation. Size 3.5 air-Q and size 4 aura-i, i-gel, and Fastrack devices were used. The necessary equipment for each simulation was placed in a box next to the manikin. Participants were given 10 min to practice with the four intubating SGD s before the trials. The manikin was placed on a hard and flat floor to simulate “on the bed” conditions (Fig. 1). According to published guidelines, the same Advanced Cardiac Life Support (ACLS) instructor performed chest compressions at a rate of 100 per minute at a depth of 5 cm according to the AH A2010 guideline (1, 9).

This study adopted a randomized crossover design to minimize learning effects. Participants inserted each of the four devices with or without chest compression. This randomization process resulted in a total of eight trials per participant, which was determined by a random numbers list. The study protocol is shown in Fig. 2. We first evaluated the utility of the four devices for ventilation with or without chest compression. Participants who achieved successful ventilation then attempted to intubate the manikin’s trachea via the intubating SGD during chest compression. In the first part of the study, participants inserted each of the four intubating SGD s, inflated their cuffs with 20 ml air for the aura-i or Fastrack device, connected the devices to a bag-valve mask, and attempted to ventilate the manikin’s lungs. A fixed volume of air was administered to evaluate the utility of the aura-i or Fastrack device in emergent airway management. We decided on 20 ml based on results of a preliminary study. We did not administer air during the air-Q trial based on the manufacturer’s instructions. Insertion times from the startpoint to the endpoint were recorded; the startpoint was when the participant picked up the intubating SGD, and the endpoint was manual ventilation after insertion, regardless of success or failure in inflating the manikin’s lungs. After successful insertion, chest compression was temporarily stopped and participants were told to perform ventilation with a 2-L bag-valve mask (Laerdal Silicone Resuscitator, Sentrum). Ventilation was considered successful when the manikin’s chest visibly rose.

In the second part of the study, participants who successfully ventilated the manikin then attempted blind tracheal intubation via the intubating SGD. Continuous chest compression was performed by the same ACLS instructor. A tracheal tube with an internal diameter of 7.0 mm (Portex, USA) was used. We did not perform this trial without chest compression because our main aim is the evaluation of tracheal intubation via intubating SGD during chest compression.
A randomised comparison of free-handed vs air-Q™ assisted fibreoptic-guided tracheal intubation in children < 2 years of age

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Summary
We prospectively compared free-handed and air-Q™ assisted fibreoptic-guided tracheal intubation in children < 2 years of age. Eighty healthy children were enrolled and randomly assigned to a technique (free-handed or air-Q assisted) and operator (trainee or attending). Time, number of attempts and manoeuvres required were assessed. There was no difference in median (IQR [range]) time to successful tracheal intubation between the free-handed (52.2 (34.8–67.7 [19.7–108.0]) s), and the air-Q assisted (60.3 (45.5–75.1 [28.1–129.0]) s; p = 0.13) groups, or the number of attempts needed. The air-Q assisted group required fewer manoeuvres to optimise the laryngeal view (median (IQR [range]) 0 (0–1 [0–2])) than the free-handed group (1 (1–1 [0–3]); p < 0.001). In conclusion, fibreoptic-guided tracheal intubation times were similar with and without the use of the air-Q, but supraglottic airway devices may be a consideration for their other practical advantages.

Introduction
Fibreoptic-guided tracheal intubation is an important part of the difficult airway algorithm, but may not be a skill that is used regularly by most clinicians. At least 30% of practising anaesthetists have limited experience with fibreoptic bronchoscopy, and may not feel confident relying on their skills in difficult airway situations [1]. Furthermore, familiarity with fibreoptic bronchoscopy in adult patients does not ensure adequate proficiency for fibreoptic-guided tracheal intubation in children [2–4].

In contrast, most anaesthetists are comfortable with the use of supraglottic airway devices in their everyday practice. In addition, these devices may be useful when difficulties with mask ventilation and/or tracheal intubation are encountered [5, 6], supporting their inclusion as rescue devices in difficult airway algorithms [7–9]. In the paediatric population, children under the age of one year have been reported to have the highest incidence of difficult airway [10, 11]. Given the technical challenges related to navigating the ultrathin fibreoptic bronchoscope needed for this age group
The use of a supraglottic airway device may be an effective option for fibreoptic-guided tracheal intubation, regardless of clinician experience.

The primary goal of this prospective randomised study was to compare the effect of using a supraglottic airway device as a conduit on the time for fibreoptic-guided tracheal intubation, by both experienced and inexperienced operators, in children < 2 years of age. The air-Q™ intubating laryngeal airway (air-Q) (Mercury Medical, Clearwater, FL, USA) has been shown to be effective in both normal and abnormal paediatric airways [13–16], and we hypothesised that fibreoptic-guided tracheal intubation through the air-Q would be faster when compared with a traditional free-handed technique.

Methods

After approval from the Ann & Robert H. Lurie Children’s Hospital Institutional Review Board, written informed consent was obtained from the parents of all patients. Registration for this study can be found at http://clinicaltrials.gov (NCT01876940). Eighty healthy children of ASA physical status 1–3 between the ages of 1 and 24 months, undergoing general anaesthesia requiring tracheal intubation for elective surgical procedures, were enrolled. Patients were not studied if they had an active respiratory infection, a history of difficult mask ventilation, a diagnosis of a congenital syndrome associated with difficult airway management or airway abnormalities (e.g. laryngomalacia, subglottic stenosis), active gastrointestinal reflux, coagulopathy or clinically significant pulmonary disease, or if they were undergoing emergency surgery.

Computer-generated randomisation was used to designate the technique (free-handed or air-Q assisted) and the operator (attending or trainee). Twenty patients were enrolled in each of the four subgroups. In the free-handed group, the trachea was fibreoptically intubated using a free-handed traditional technique [12]. Patients in the air-Q assisted group had an air-Q placed as a conduit for fibreoptic-guided tracheal intubation. The trainees included in this study had minimal prior experience with paediatric fibreoptic bronchoscopes, and watched a video outlining the steps for fibreoptic-guided tracheal intubation through an air-Q before participating (http://www.youtube.com/watch?v=My8oYzM5lJM).

All patients received a standard inhalational induction with 8% sevoflurane in 70% nitrous oxide and 30% oxygen. Intravenous access was obtained after induction. Rocuronium 0.6 mg.kg⁻¹ was given at this point in the free-handed group, and after air-Q placement and leak pressure testing was completed in the air-Q assisted group. The nitrous oxide was discontinued and an end-tidal sevoflurane concentration of > 3% was established in all patients before airway management.

The time for free-handed fibreoptic-guided tracheal intubation was measured from the removal of the facemask until confirmation of end-tidal carbon dioxide.

In the air-Q assisted group, an air-Q was placed using a standard midline technique. The size of the air-Q was determined according to the manufacturer’s guidelines based on the patient’s weight. The air-Q intracuff pressure was standardised to 40 cmH₂O using a cuff pressure manometer. The airway leak pressure was measured at 3 l.min⁻¹ of fresh gas flow with the expiratory valve closed until equilibrium was seen on the pressure gauge (not allowed to exceed 40 cmH₂O) [17]. Each clinician was allowed a maximum of three attempts to achieve correct placement of the air-Q. An attempt was to be counted each time the device was inserted into the mouth. Failure was defined as the absence of end-tidal carbon dioxide and chest rise, inability to deliver 7-ml.kg⁻¹ breaths, notable airway obstruction or spontaneous dislodgement of the device. For the air-Q assisted group, two separate times were recorded: (a) the time for successful placement of the air-Q, which started with the removal of the facemask and ended when the presence of end-tidal carbon dioxide was detected; and (b) the time for tracheal intubation, which started with disconnection of the circuit from the air-Q, and ended when the presence of end-tidal carbon dioxide was confirmed.

Only cuffed tracheal tubes (Mallinckrodt Inc., St Louis, MO, USA) were used in this study. Tracheal intubation was performed with a fibreoptic bronchoscope (LF-P or LF-DP) (Olympus America, Melville, NY, USA). The fibreoptic view of the larynx was graded using a previously described scale [18] by the attending anaesthetist for the air-Q assisted group only. In both groups, airway manoeuvres such as jaw
thrust, tongue displacement, neck extension, gentle advancement or withdrawal of the device, or anterior laryngeal pressure, were documented if needed to improve suboptimal grades of view, or required for passage of the tracheal tube. Three attempts for tracheal intubation were allowed, with a failed attempt defined as the removal of the fibreoptic bronchoscope from the airway or arterial desaturation < 85%. The clock was restarted for each attempt. After three attempts, the trachea would be intubated using direct laryngoscopy. Following successful tracheal intubation in the air-Q assisted group, the air-Q was removed using a second tracheal tube as a stabilising rod. Complications such as regurgitation, laryngospasm, bronchospasm and desaturation were also noted. At the end of the surgical procedure, the tracheal tube was removed after reversal of the neuromuscular blockade, when standard extubation criteria were met.

The primary outcome measure of this study was the time to successful tracheal intubation. Power analysis using a one-way ANOVA study design determined that a sample size of 17 subjects per group would allow 90% power to detect a 10-s difference using an F-test with a 0.01 significance level to allow multiple comparisons. A common SD within a group was assumed to be 20 s. Twenty subjects per subgroup (40 patients per technique) were recruited to allow for potential dropouts. Power analysis was performed using PASS version 12 (NCSS, LLC Kaysville, UT, USA).

Intra-operative data were recorded using a standardised data collection sheet and entered into a database using Microsoft Excel 2010, then imported into Stata 12 software (StataCorp LP, College Station, TX, USA) for statistical analysis. Times to intubation were compared using the Kruskal–Wallis H-test and subgroup comparisons were compared using the Mann–Whitney U-test with Bonferroni correction for multiple comparisons. Categorical variables were compared using Fisher’s exact test. Statistical significance was taken as p < 0.05.

Results
Of the eighty patients enrolled, two were not studied for analysis due to failed fibreoptic-guided tracheal intubation within three attempts (Fig. 1). Both patients were in the trainee free-handed fibreoptic subgroup, and direct laryngoscopy was used to intubate the trachea without difficulty. Patients’ characteristics are presented in Table 1. Data regarding air-Q placement and fibreoptic view in the air-Q assisted group are presented in Table 2.

No differences were found in times to tracheal intubation or number of attempts and manoeuvres for tracheal tube passage. Fewer manoeuvres were necessary to obtain an adequate laryngeal view with the air-Q assisted group (Table 3). Analysis of the air-Q assisted subgroups did not show a significant difference in the median (IQR [range]) time for successful fibreoptic guided tracheal intubation between attendings (50.8 (41.0–62.6 [28.1–129.0]) s) and trainees (66.4 (52.2–82.0 [41.7–122.0]) s; p = 0.3). There was no significant difference in the complication rates between the two techniques. Intra-operative arterial desaturation occurred in six patients (one in the air-Q assisted and five in the free-handed group). There were no instances of regurgitation, laryngospasm or bronchospasm.

Discussion
Contrary to our initial hypothesis, the use of an air-Q as a conduit did not reduce the time necessary for successful fibreoptic tracheal intubation when compared with a free-handed technique in children younger than two years of age. In addition, the type of technique used did not seem to make a difference with less experienced operators.

Several studies have demonstrated the efficacy of supraglottic airway device assisted fibreoptic-guided tracheal intubation in children [6, 13, 15, 19–21], even when traditional techniques have failed [6, 22], suggesting that this technique may be an indispensable anaesthetic skill [23]. Successful placement of the air-Q on the first attempt may suggest that most clinicians, regardless of experience, should not have difficulty with its insertion. When properly placed, a supraglottic airway device can provide a direct channel to the larynx, improving orientation and identification of laryngeal structures. To the best of our knowledge, it has not been previously shown in children whether the use of a supraglottic airway device has an effect on fibreoptic-guided tracheal intubation times.
Although not statistically significant, the air-Q assisted technique in this study resulted in slightly higher first attempt success rates for fibreoptic-guided tracheal intubation. The use of a supraglottic airway device may be helpful in keeping the relatively thin paediatric fibreoptic bronchoscope in the midline position. Other advantages to consider include the potential for relieving severe upper airway obstruction and improving ventilation and oxygenation, such as in patients with Pierre Robin syndrome [13, 16, 24, 25].

Table 1 Characteristics of patients undergoing free-handed or air-Q assisted fibreoptic-guided intubation. Values are mean (SD [range]) or number.

<table>
<thead>
<tr>
<th></th>
<th>Free-handed (n = 40)</th>
<th>air-Q assisted (n = 40)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age; months</td>
<td>11.4</td>
<td>10.5</td>
</tr>
<tr>
<td></td>
<td>(6.4 [2-22])</td>
<td>(6.8 [2-23])</td>
</tr>
<tr>
<td>Weight; kg</td>
<td>9.4</td>
<td>8.8</td>
</tr>
<tr>
<td></td>
<td>(2.2 [4.5-13.6])</td>
<td>(2.2 [4.2-13.2])</td>
</tr>
<tr>
<td>Height; cm</td>
<td>73.6</td>
<td>71.5</td>
</tr>
<tr>
<td></td>
<td>(9.1 [52.0-88.9])</td>
<td>(8.7 [54.0-88.9])</td>
</tr>
<tr>
<td>ASA status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>28</td>
<td>21</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
<td>16</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Type of procedure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENT</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>General</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Medical/minimal</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>invasive Neurosurgery</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Ophthalmological</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Orthopaedic</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Plastic</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Urological</td>
<td>18</td>
<td>20</td>
</tr>
</tbody>
</table>

ASA, American Society of Anesthesiology; ENT, ear, nose and throat.

Table 2 Details of air-Q placement in 40 patients. Values are number (proportion) or median (IQR [range]).

<table>
<thead>
<tr>
<th></th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of air-Q</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>8 (20%)</td>
</tr>
<tr>
<td>1.5</td>
<td>32 (80%)</td>
</tr>
<tr>
<td>Number of attempts for placement</td>
<td></td>
</tr>
<tr>
<td>Leak pressure; cmH2O</td>
<td>18 (15-22 [10-30])</td>
</tr>
<tr>
<td>Time for successful placement; s</td>
<td>14.0 (12.3-19.0 [8.9-27.3])</td>
</tr>
<tr>
<td>Fibreoptic grade of view</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>15 (38%)</td>
</tr>
<tr>
<td>2</td>
<td>7 (18%)</td>
</tr>
<tr>
<td>3</td>
<td>5 (13%)</td>
</tr>
<tr>
<td>4</td>
<td>3 (8%)</td>
</tr>
<tr>
<td>5</td>
<td>10 (25%)</td>
</tr>
</tbody>
</table>

Fibreoptic grade of view: 1, larynx only seen; 2, larynx and epiglottis posterior surface seen; 3, larynx and epiglottis tip of anterior surface seen, < 50% visual obstruction of epiglottis to larynx; 4, epiglottis downfolded and its anterior surface seen, > 50% visual obstruction of epiglottis to larynx; 5, epiglottis downfolded and larynx cannot be seen directly.
In addition, these devices allow for continuous oxygenation during fibreoptic-guided tracheal intubation [20, 26], which is desirable in patients with limited oxygen reserve.

Our results also showed the air-Q assisted group required less manoeuvres to improve the view for access to the glottis. This may be a consideration when working with a limited number of staff, or those who may not be familiar with assisting in fibreoptic-guided tracheal intubation. Finally, in this study, the absence of failed tracheal intubations in the air-Q assisted group, when compared with the free-handed fibreoptic group, may further suggest that its use for fibreoptic-guided tracheal intubations may be helpful for clinicians with minimal experience. Further studies will be needed to make more definitive conclusions.

In trainees acquiring fibreoptic-guided tracheal intubation skills, starting with a supraglottic airway device as a guide may help improve their learning process. This technique, however, should not be a replacement for traditional free-handed fibreoptic bronchoscopy skills, and may not be suitable when significant head and neck pathology exists, such as a large tumour. In addition, when nasal intubation is needed, or if a patient has limited mouth opening, free-handed fibreoptic bronchoscopy skills will still be necessary. It is also important for the clinician to rehearse the removal process of the supraglottic airway device after tracheal intubation to ensure familiarity. We have previously demonstrated that the air-Q may be safely removed without dislodgement of the tracheal tube in children [15, 16, 21].

Our study should only be interpreted in the context of its limitations. First, only children with normal airways were enrolled, and these results may not apply to infants with a difficult airway. Second, only the air-Q was used in this study, and our results may not be applicable to all other supraglottic airway devices. Last, in this study, we did not differentiate times for laryngeal view, carinal view or passage of the tracheal tube. Future studies looking at these separate time points may help discern if the difficulties encountered were due to disorientation, manipulation of the bronchoscope into the trachea after views, or with passage of the tracheal tube.

In conclusion, fibreoptic-guided tracheal intubation times were similar with and without the use of the air-Q as a conduit, but a supraglottic airway device assisted technique may be preferred by some clinicians for its other practical advantages.

Competing interests
No external funding or competing interests declared.

References


A Clinical Evaluation of the Intubating Laryngeal Airway as a Conduit for Tracheal Intubation in Children

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BACKGROUND: The air-Q™ Intubating Laryngeal Airway (ILA) (Cookgas LLC, Mercury Medical, Clearwater, FL) is a supraglottic airway device available in pediatric sizes, with design features to facilitate passage of cuffed tracheal tubes when used to guide tracheal intubation. We designed this prospective observational study of the ILA to assess the ease of its placement in paralyzed pediatric patients, determine its position and alignment to the larynx using a fiberoptic bronchoscope, gauge its efficacy as a conduit for fiberoptic intubation with cuffed tracheal tubes, and evaluate the ability to remove the ILA without dislodgement of the tracheal tube after successful tracheal intubation.

METHODS: One hundred healthy children, aged 6 months to 8 years, ASA physical status I to II, and scheduled for elective surgery requiring general endotracheal anesthesia were enrolled in this prospective study. Based on the manufacturer’s guidelines, each patient received either a size 1.5 or 2.0 ILA according to their weight. The number of attempts for successful insertion, leak pressures, fiberoptic grade of view, number of attempts and time for tracheal intubation, time for ILA removal, and complications were recorded.

RESULTS: ILA placement, fiberoptic tracheal intubation, and ILA removal were successful in all patients. The size 1.5 ILA cohort had significantly higher rates of epiglottic downfolding compared with the size 2.0 ILA cohort (P < 0.001), despite adequate ventilation variables. When comparing fiberoptic grade of view to weight, a moderate negative correlation was found (r = −0.41, P < 0.001), indicating that larger patients tended to have better fiberoptic grades of view. The size 1.5 ILA cohort had a significantly longer time to intubation (P = 0.04) compared with the size 2.0 ILA cohort. However, this difference may not be clinically significant because there was a large overlap of confidence bounds in the average times of the size 1.5 ILA (27.0 ± 13.0 seconds) and size 2.0 ILA cohorts (22.7 ± 6.9 seconds). When comparing weight to time to tracheal intubation, a weak correlation that was not statistically significant was found (r = −0.17, P = 0.41), showing that time to intubation did not differ significantly according to weight, despite higher fiberoptic grades in smaller patients.

CONCLUSIONS: The ILA was easy to place and provided an effective conduit for tracheal intubation with cuffed tracheal tubes in children with normal airways. Additionally, removal of the ILA after successful intubation could be achieved quickly and without dislodgement of the tracheal tube. Because of the higher incidence of epiglottic downfolding in smaller patients, the use of fiberoptic bronchoscopy is recommended to assist with tracheal intubation through this device. (Anesth Analg 2011;112:176–82)
There were 4 main objectives for this prospective observational study of the ILA: first, to assess the ease of placement; second, to determine the position of the ventilating orifice in relation to the larynx using a fiberoptic bronchoscope, indicating the feasibility of blind tracheal intubation by grading the quality of airway alignment; third, to test its efficacy as a conduit for fiberoptic intubation with cuffed tracheal tubes in paralyzed pediatric patients; and fourth, to evaluate the ability to remove the ILA without dislodgement of the tracheal tube after successful tracheal intubation.

**METHODS**

This study was approved by the IRB, and written informed consent was obtained from the parents of all patients. One hundred eligible pediatric patients scheduled for elective surgery to receive general endotracheal anesthesia were enrolled in this study over a 6-week period. Inclusion criteria were patients with ASA physical status I and II, ages 6 months to 8 years, weighing 7 to 30 kg. Patients were excluded if they had a history of cardiopulmonary disease, severe gastrointestinal reflux, or abnormal airway anatomy, which was assessed by the following: passive mouth opening, micrognathia, thyromental distance, and submental compliance. Four study investigators (NJ, LES, IIM, and AGR) who were experienced with fiberoptic intubations through the ILA performed all of the intubations in this study. Before this study, all study investigators had used the ILA for tracheal intubation in at least 25 patients including both normal and difficult airway patients and were considered experienced for the purposes of this study.

After placement of standard monitors, inhaled anesthesia was induced using 8% sevoflurane in 70% nitrous oxide and 30% oxygen. An IV cannula was placed, and 0.6 mg/kg rocuronium was administered to provide neuromuscular blockade. Nitrous oxide was discontinued and an end-tidal sevoflurane concentration of >3% was established in all patients before placement of the ILA. A disposable ILA was used in all patients; those weighing between 7 and 17 kg received a size 1.5 ILA, and patients between 17 and 30 kg received a size 2.0 ILA, according to the manufacturer’s guidelines. The anesthesiologist waited at least 2 minutes after rocuronium administration for optimal laryngeal relaxation. The ILA was then inserted after application of jaw thrust, using the standard midline technique, and the cuff of the ILA was inflated following manufacturer recommendations. Successful placement was determined by the ability to achieve at least 5 mL/kg tidal volume and bilateral chest excursion with the presence of a square wave capnogram upon delivery of a positive pressure breath. The airway leak pressure was measured while observing the pressure gauge with the expiratory valve closed and a fresh gas flow of 5 L/min until an audible noise was heard over the patient’s mouth. Airway pressures were not allowed to exceed 40 cm H₂O.

A fiberoptic bronchoscope (LF-P outer diameter 2.2 mm, LF-DP outer diameter 3.1 mm, LF-2 outer diameter 3.8 mm, LF-V outer diameter 4.1 mm; Olympus America, Inc., Melville, NY) was loaded with the appropriately sized cuffed tracheal tube (Mallinckrodt Inc., St Louis, MO) based on the age of the patient, and inserted through the lumen of the ILA with the 15-mm connector removed. A view of the glottic opening was recorded from the airway tube of the ILA just proximal to the ventilating orifice. Video images of the fiberoptic view were obtained using a digital camera and stored on a personal computer for analysis and grading by an independent observer (SS). The images were graded according to a score of 1 to 5 defined as follows: grade 1 = only larynx seen; grade 2 = larynx and epiglottis posterior surface seen; grade 3 = larynx and epiglottis tip of anterior surface seen, <50% visual obstruction of epiglottis to larynx; grade 4 = epiglottis downfolded and its anterior surface seen, >50% visual obstruction of epiglottis to larynx; and grade 5 = epiglottis downfolded and larynx cannot be seen directly. Images of all 5 grades of glottic view through the ILA are shown in Figure 2. According to the discretion of the anesthesiologist, maneuvers were allowed if the view was grade 2 or worse, in an attempt to optimize the laryngeal view and facilitate fiberoptic navigation past the epiglottis. The following manipulations were allowed: neck extension or flexion, jaw thrust, and gentle advancement or withdrawal of the device. Scores were recorded before and after the manipulations to see whether these maneuvers improved the laryngeal view. Once the carina was visualized with the bronchoscope, the tracheal tube was passed through the ILA and into the trachea. An independent observer (RJK) measured the time for successful tracheal intubation from the time the fiberoptic bronchoscope entered the ILA until reconnection of...
the anesthesia circuit to the tracheal tube. Successful tracheal intubation was confirmed with auscultation of bilateral breath sounds and end-tidal carbon dioxide.

After successful tracheal intubation, the ILA cuff was deflated and removed using the manufacturer’s removal stylet (Fig. 1A) to stabilize the tracheal tube. The time for removal of the ILA started with the disconnection of the breathing circuit from the tracheal tube and ended at the time of reconnection. End-tidal carbon dioxide was verified to ensure that the tracheal tube had not been dislodged during ILA removal. The patient was ventilated with 100% oxygen throughout the intubation process to minimize the risk of oxygen desaturation.

The intubation was recorded as a failure and the patient was intubated by direct laryngoscopy if correct placement of the ILA was not achieved after 3 attempts, fiberoptic bronchoscopy was not successful in intubating the trachea after 2 attempts, the tracheal tube was dislodged during ILA removal, or there were 2 clinically significant instances of oxygen desaturation (Spo2 <90). At the end of the surgical procedure, the tracheal tube was removed after reversal of muscle relaxant and when standard extubation criteria were met. Complications such as tracheal placement as evidenced by blood staining of the ILA, aspiration, bronchosperm, laryngospasm, oxygen desaturation (Spo2 <90), and postextubation stridor were also recorded. Data collection regarding postoperative sore throat was not included in this study, because many of the children were too young to objectively report this complication. Patient follow-up was conducted according to standard postoperative protocols at our institution.

Based on previous experience with this device, we anticipated that the time to intubation in the ILA 1.5 group would be approximately 30 ± 15 seconds and that time to intubation in the ILA 2.0 group would be approximately 20 ± 15 seconds. Using an α of 0.05 and desired power of 90%, we estimated that 48 patients would be needed in each group to demonstrate a statistically significant difference. The study was designed with 50 patients in each group to account for possible failed intubation or exclusion from the study for any reason.

Data were recorded intraoperatively using a standardized data collection sheet and analyzed using Microsoft Excel Spreadsheet and the statistical software PASW Statistics 18 (SPSS Inc., Chicago, IL). Statistical comparisons between cohorts were made using Student t tests for continuous data, χ2 tests for categorical data, and Mann-Whitney U for ordinal data. A Spearman ρ correlation coefficient was calculated for the relationship between a patient’s weight and fiberoptic grade of view and fiberoptic view to time to intubation. A Pearson correlation coefficient was calculated for the relationship between patient’s weight and time to tracheal intubation.

RESULTS

We studied 72 male and 28 female pediatric patients, with a mean weight of 17 ± 5.5 kg, and a mean age of 4.2 ± 2.1 years, who were divided into 2 cohorts of 50 according to the size of ILA placed. Patients underwent a variety of procedures including urological (n = 31), otolaryngological (n = 29), orthopedic (n = 10), general (n = 9), ophthalmological (n = 9), plastic (n = 5), and dental (n = 5) surgery, as well as medical imaging (n = 2). Demographic information and summary of results for both cohorts are presented in Table 1. No patients were excluded after enrollment for protocol violation or refusal to participate.

Insertion of the ILA with subsequent ventilation was successful in all 100 patients. In 99 patients, this was achieved on the first attempt. One case required a second attempt because the mask tip folded back upon itself during insertion as verified by fiberoptic bronchoscopy. There was no clinical evidence of airway obstruction or oxygen desaturation in any of the patients. The mean airway leak pressure for all patients was 16.6 ± 5.5 cm H2O. There was no statistically significant difference in leak pressures between the 2 ILA sizes (P = 0.08).

Overall, 31% had a grade 1 view, 21% a grade 2 view, 12% a grade 3 view, 9% a grade 4 view, and 27% a grade 5 view. Details of fiberoptic grading for both cohorts are presented in Table 1. Of the 27 patients with a grade 5 view, 22 (81.5%) had a size 1.5 ILA placed. Of the 6 patients weighing <10 kg, all had grade 5 views. The grade of view was significantly better in the size 2.0 ILA cohort (P < 0.001).

When comparing the patient’s weight and the fiberoptic grade of view, a moderate negative correlation that was
A moderate positive correlation was found for the relationship between the fiberoptic grade of view and time to intubation ($r = 0.31$, $P = 0.01$), indicating shorter intubation times with better fiberoptic view. Tracheal intubation was successful in all patients. Insertion was successful on the first attempt in 97 patients and on the second attempt in 3 patients. In these patients, a second attempt was necessary because of secretions obscuring the fiberoptic view. Successful intubation took an average of 24.8 ± 10.6 seconds across all 100 patients. Intubation times ranged from 11.6 to 84.9 seconds, and there were no instances of oxygen desaturation from patients’ baselines. In the size 1.5 ILA cohort, intubation took an average of 27.0 ± 13.0 seconds. The time to intubation in the size 2.0 cohort, 22.7 ± 6.9 seconds, was significantly faster ($P = 0.04$), but may not be clinically significant. The relationship between the time to intubation and the child’s weight across all patients (Fig. 4) showed a weak correlation that was not statistically significant ($r = -0.17$, $P = 0.09$).

<table>
<thead>
<tr>
<th>Table 1. Demographic and Descriptive Statistics Regarding Placement and Tracheal Intubation Through the Intubating Laryngeal Airway (ILA)</th>
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<tbody>
<tr>
<td>Gender, male:female</td>
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<tr>
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<td>Age, y</td>
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<td>Weight, kg</td>
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<tr>
<td>ILA insertion</td>
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<td>2nd attempt</td>
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<td>ILA leak pressure, cm H$_2$O</td>
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<tr>
<td>Time for intubation, s</td>
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<tr>
<td>Time for ILA removal, s</td>
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</table>

Data are presented as mean ± SD (range).

* Fiberoptic grade was defined as follows: grade 1 = only larynx seen; grade 2 = larynx and epiglottis posterior surface seen; grade 3 = larynx and epiglottis tip of anterior surface seen, 50% visual obstruction of epiglottis to larynx; grade 4 = epiglottis downfolded and its anterior surface seen, >50% visual obstruction of epiglottis to larynx; and grade 5 = epiglottis downfolded and larynx cannot be seen directly.

* $P < 0.05$ designates a significant difference between cohorts.

Figure 3. Fiberoptic grade of view through the Intubating Laryngeal Airway in relation to weight of patient. A moderate negative correlation that was statistically significant was found ($r = -0.41$, $P < 0.001$), indicating that larger patients had better fiberoptic grades of view (Fig. 3). A moderate positive correlation was found for the relationship between the fiberoptic grade of view and time to intubation ($r = 0.31$, $P = 0.01$), indicating shorter intubation times with better fiberoptic view. Tracheal intubation was successful in all patients. Insertion was successful on the first attempt in 97 patients and on the second attempt in 3 patients. In these patients, a second attempt was necessary because of secretions obscuring the fiberoptic view. Successful intubation took an average of 24.8 ± 10.6 seconds across all 100 patients. Intubation times ranged from 11.6 to 84.9 seconds, and there were no instances of oxygen desaturation from patients’ baselines. In the size 1.5 ILA cohort, intubation took an average of 27.0 ± 13.0 seconds. The time to intubation in the size 2.0 cohort, 22.7 ± 6.9 seconds, was significantly faster ($P = 0.04$), but may not be clinically significant. The relationship between the time to intubation and the child’s weight across all patients (Fig. 4) showed a weak correlation that was not statistically significant ($r = -0.17$, $P = 0.09$).
INTUBATING LARYNGEAL AIRWAY AS A CONDUIT FOR TRACHEAL INTUBATION IN CHILDREN

Figure 4. Time to tracheal intubation in relation to weight of patient. A weak correlation that was not statistically significant was found ($r = -0.17, P = 0.09$). This shows that time to intubation did not differ significantly according to weight, despite higher fiberoptic grades in smaller patients. $x =$ size 1.5 Intubating Laryngeal Airway; $+ =$ size 2.0 Intubating Laryngeal Airway.

Of the 69 patients with a grade 2 view or worse, 41 (59.0%) received a maneuver in an attempt to optimize the view that resulted in an improvement by $\geq 1$ grade in 39 cases (95.1%). The maneuvers performed were jaw thrust on 34 patients, head extension on 5 patients, and gentle advancement of the ILA in 2 patients.

The ILA was successfully removed while keeping the tracheal tube in place in all 100 patients. The mean time for removal was 11.2 $\pm$ 4.6 seconds. The time for removal did not differ significantly between cohorts ($P = 0.355$).

There were no cases recorded as failures, and no instances of blood staining of the ILA, aspiration, bronchospasm, laryngospasm, oxygen desaturation (SpO$_2$ <90), or postextubation stridor reported in any patients.

DISCUSSION

The ILA is currently the only available supraglottic device in pediatric patients designed to act as a conduit for tracheal intubation with cuffed tracheal tubes. The traditional LMA has been used for this purpose with success, but a series of modifications to the tracheal tube or LMA may be required for optimal results and can be impractical in the difficult airway. In this study, the ILA was successfully inserted in all patients, and leak pressures were consistent with earlier studies using the LMA in children. Even in cases of complete epiglottic downfolding, ventilation was adequate. This is consistent with previous studies that compared LMA positioning with airway patency. Additionally, fiberoptic-guided tracheal intubation and subsequent removal of the ILA while leaving the tracheal tube in place were completed quickly without complications in all patients.

Our observation of a frequent incidence of partial or complete obstruction by the epiglottis upon fiberoptic examination is consistent with earlier literature regarding pediatric LMAs. Indeed, our findings show that smaller sized patients exhibited greater obstruction of the glottic opening compared with larger patients. A potential explanation for this is the combination of a large, floppy epiglottis in smaller children with the use of neuromuscular blockade. This may have predisposed the epiglottis to be pushed downward by the front end of the ILA when using the standard midline insertion technique as recommended by the manufacturer. We may have found lower rates of epiglottic downfolding by using the rotational method of ILA insertion, a technique that was shown to obtain an optimal glottic view in a previously published case series. With the rotational method of insertion, the LMA has also been shown to have a higher rate of success in smaller patients versus standard insertion technique. However, even in cases of complete visual obstruction of the larynx through the ILA by the epiglottis, the anesthesiologist was able to bypass the epiglottis to gain a full view of the vocal cords in all patients. Additionally, the use of airway manipulations while attempting to intubate through the ILA improved the laryngeal view by raising the epiglottis anteriorly to open the laryngeal inlet. Although studies have shown high success rates of blind intubation with the Intubating LMA in adult patients, the high rates of epiglottic obstruction observed in our study lead us to advise against blind intubations through the ILA in children. Similarly, blind intubations through the LMA have also been cautioned against for pediatric patients because of the risk of laryngeal trauma or esophageal intubation.

During intubation through the ILA, there is a period when the patient is disconnected from the breathing circuit. Although these intubation times reflect an apneic period when the patient is at potential risk for oxygen desaturation, our longest intubation times were still within acceptable clinical limits. This correlates with our findings that none of the patients exhibited oxygen desaturation after adequate oxygen administration. Of note, as part of the study, the investigators briefly paused advancement of the fiberoptic bronchoscope within the lumen of the ILA to optimize the laryngeal view for subsequent grading. Also, the size 2.0 ILA had shorter intubation times when compared with the smaller size. However, this difference may not be clinically significant given the large overlap of confidence bounds, the nonsignificant correlation coefficient that compared tracheal intubation times to weight across all patients, and the absence of oxygen desaturation. Fiberoptic intubation through the ILA may be clinically acceptable in patients with normal cardiopulmonary reserve, but larger-scale studies are indicated to further confirm these findings.

When attempting to remove the LMA after tracheal intubation with a cuffed tracheal tube, there is a potential risk of accidental dislodgement of the tracheal tube or pilot balloon rupture. This might lead the clinician to leave the supraglottic airway in place until extubation. However, when using the ILA, the shorter and wider airway tube allows smoother passage of the pilot balloon. Furthermore,
the ability to stabilize the tracheal tube with the removal stylet allows the clinician greater control of the tracheal tube during removal of the ILA. Given these features, removal of the ILA after tracheal intubation was performed expeditiously without any oxygen desaturation, pilot balloon breakage, or dislodgement of the tracheal tube in all patients. This may be particularly useful in clinical practice as the paradigm is shifting toward the use of cuffed tracheal tubes in children. In addition to the use of the ILA removal stylet, several other methods of stabilizing the tracheal tube during removal of the ILA have also been described. This includes the use of a second tracheal tube, a fiberoptic bronchoscope, or an airway exchange catheter. The removal stylet may be the most user friendly, but alternative modalities are an option if the removal stylet is not available or the clinician is not comfortable with its use.

This study had several limitations. First, only low-risk patients with normal airways were enrolled; second, there was no performance comparison with an established supraglottic device; third, our patients received muscle relaxants and our results may be less applicable to patients who are spontaneously breathing; fourth, the ILA intracuff pressures were not checked after cuff inflation; and fifth, airway manipulations to facilitate tracheal intubation were not standardized in all patients. Finally, this study was a pilot evaluation of the use of the ILA as a conduit for tracheal intubation in healthy patients. Further prospective comparison trials with a larger number of patients, particularly infants weighing <10 kg who are at higher risk for airway difficulty, are required to more fully judge both the safety of this device and the feasibility of blind tracheal intubation.

In summary, the ILA was easy to place and provided an effective conduit for tracheal intubation with cuffed tracheal tubes in children with normal airways. Additionally, removal of the ILA after successful intubation could be achieved quickly and without dislodgement of the tracheal tube. Because of the higher incidence of epiglottic downfolding in smaller patients, the use of fiberoptic bronchoscopy is recommended to assist with tracheal intubation through this device.

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SUCCESSFUL TRACHEAL INTUBATION THROUGH AN INTUBATING LARYNGEAL AIRWAY IN PEDIATRIC PATIENTS WITH AIRWAY HEMORRHAGE

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Abstract—Background: This case report describes the use of the air-Q intubating laryngeal airway (air-Q ILA; Cookgas LLC, St. Louis, MO) for airway rescue and a conduit for blind tracheal intubation in two pediatric patients with failed rapid sequence intubation and difficult airways secondary to airway bleeding in the emergency department (ED). Objectives: To describe the use of a new supraglottic rescue device in the management of the pediatric patient’s difficult airway in the emergency setting. Case Report: Case 1 was a 5-year-old boy who presented to the ED for bleeding one day after his tonsillectomy. After a rapid sequence intubation, direct laryngoscopy was difficult, with copious bleeding in the oropharynx and inability to visualize the glottis. After two failed direct laryngoscopic attempts to intubate, a size-2 air-Q ILA was inserted. A cuffed 5.0-mm inner diameter (ID) endotracheal tube (ETT) was blindly inserted through the lumen of the air-Q ILA into the trachea successfully. Case 2 was a 13-year-old boy who presented to the ED with a large nasopharyngeal laceration from a motor vehicle accident. After a rapid sequence intubation, direct laryngoscopy showed copious blood with no glottic visualization. A size 3 Laryngeal Mask Airway Classic™ (cLMA; LMA North America Inc., San Diego, CA) was inserted with a large airway leak, and blind ETT insertion via the cLMA was unsuccessful. Subsequently, a size-2.5 air-Q ILA was inserted and adequate ventilation was restored. A cuffed 6.0-mm ID ETT was blindly inserted through the air-Q ILA into the trachea successfully. Conclusion: Two cases of failed laryngoscopy in pediatric patients with blood in the airway are described. In each case, insertion of an air-Q ILA was followed by successful blind tracheal intubation via the lumen of the air-Q ILA. © 2010 Elsevier Inc.

Keywords—laryngeal mask airway (LMA); rapid sequence intubation; difficult airway in pediatrics; emergency airway in pediatrics; air-Q ILA; proseal LMA

INTRODUCTION

Although the development of the intubating laryngeal mask airway (LMA), the LMA-Fastrach™ (ILMA), and the LMA-CTrach™ (LMA North America Inc., San Diego, CA) have facilitated emergency tracheal intubation through a supraglottic airway in the unanticipated difficult airway in adults, such advancements have not been available for children (1–4). The air-Q™ intubating laryngeal airway (air-Q ILA) (Cookgas LLC, St. Louis, MO) is a new supraglottic airway recently introduced into pediatric practice. It shares common features with the LMA-Classic™ (cLMA) and the ILMA. It is inserted in the same manner as a cLMA while providing a conduit for tracheal intubation in a similar fashion as the ILMA (5). In contrast to the ILMA and LMA-CTrach™, the air-Q ILA offers pediatric sizes appropriate for tracheal intubation in infants and children (6). These features make it potentially useful as a rescue airway device after failed tracheal intubation. Although rapid sequence intubation (RSI) in adult and pediatric patients in the emergency setting becomes an option only after failed tracheal intubation, the use of the air-Q ILA may be a novel rescue option for the pediatric airway.
department (ED) is associated with a high degree of success in the hands of emergency physicians, sometimes there is a need to rescue the airway with either a supraglottic device or cricothyrotomy (7–11). The latter is more common in adult patients, and utilization of an emergent surgical airway is much rarer in the pediatric population (11,12). We report two cases of blind tracheal intubation performed successfully in the ED through the air-Q ILA in children after failed RSI with direct laryngoscopy.

CASE REPORTS

Case 1

A 5-year-old 28-kg boy presented to the ED of a small community hospital for bleeding 1 day after his tonsillectomy. At the time of the tonsillectomy, he had a Cormack and Lehane Grade II view (only the posterior portion of the glottis was seen; typically associated with easy tracheal intubation with direct laryngoscopy) upon direct laryngoscopy with a Miller 2 blade (13). He was obese and had a history of obstructive sleep apnea. In the ED, the patient’s blood pressure was 98/46 mm Hg and respiratory rate was 40 breaths/min while maintaining an oxygen saturation of 97% on 6 L oxygen via facemask. Our plan was to perform RSI with direct laryngoscopy with a gum elastic bougie, with access to an air-Q ILA for rescue ventilation and a conduit for tracheal intubation if direct laryngoscopy was unsuccessful. After RSI with ketamine and rocuronium, a laryngoscopic view with a Miller 2 blade was very difficult secondary to copious bleeding from the oropharynx, with inability to visualize the glottic opening. After two failed attempts to intubate with a Miller 2 and a Macintosh 2 blade, respectively, a size-2 disposable air-Q ILA was easily inserted while maintaining crirocoid pressure. A good seal was confirmed by ventilation of the lungs, without an audible leak. Because a fiberoptic bronchoscope was unavailable, a cuffed 6.0-mm ID ETT was blindly inserted into the trachea through the lumen of the air-Q ILA, which was successful upon the first attempt. Proper placement of the ETT was confirmed with end-tidal carbon dioxide, and the patient was taken to the operating room for repair of the laceration with the air-Q ILA left in situ. Postoperatively, both intubated patients were taken to the Intensive Care Unit. Neither patient developed any serious respiratory sequelae or signs of aspiration. Both patients were discharged after uncomplicated recoveries.

Case 2

A 13-year-old 40-kg boy presented to the ED with a large nasopharyngeal laceration he sustained in a motor vehicle accident. In the ED, he was hemodynamically stable but disoriented. A potentially difficult laryngoscopy was predicted due to extensive bleeding in the nasopharynx. A decision was made to proceed with RSI along with a gum elastic bougie, with both the cLMA and the air-Q ILA available for rescue ventilation, and a conduit for tracheal intubation if direct laryngoscopy were to fail. After administration of thiopental and succinylcholine, the laryngoscopic view with a Macintosh 3 blade was very difficult, revealing only copious blood in the posterior pharynx, despite aggressive suctioning. A size-3 cLMA was inserted easily, with an audible leak upon delivery of positive pressure. An attempt to blindly intubate through the cLMA with a 5.0-mm ID cuffed ETT was unsuccessful. The patient regained spontaneous breathing, and a surgeon remained at the bedside, ready to perform a surgical airway. The patient was maintaining SpO2 of 90%. After a second dose of thiopental and succinylcholine, the cLMA was removed and a size-2.5 disposable air-Q ILA was inserted as a last resort before proceeding to a surgical airway. Adequate ventilation with good chest rise was established with the air-Q ILA and no leak was noted. Because a fiberoptic bronchoscope was unavailable, a cuffed 6.0-mm ID ETT was blindly inserted into the trachea through the lumen of the air-Q ILA, which was successful upon the first attempt. Proper placement of the ETT was confirmed with end-tidal carbon dioxide, and the patient was taken to the operating room for repair of the laceration with the air-Q ILA left in situ.

DISCUSSION

Failed laryngoscopy and difficult mask ventilation are very rare in pediatric patients. A study of the National Emergency Airway Registry database found that only 0.56% of pediatric intubations require cricothyrotomy (7). This percentage may be decreased by adoption of RSI techniques, increased use of video-guided intubation, new difficult airway devices, and increased prevalence of residency-trained emergency physicians (14). The surgical airway is a rare event in the pediatric population, particularly in children under 8 years of age. The cricothyroid membrane in adults averages 13.7 mm in length and 12.4 mm in width (15,16). In contrast, in young infants, the cricothyroid membrane has a mean length of only 2.6 ± 0.7 mm and width of 3 ± 0.63 mm (17). Thus, there is a larger target for incision offered by the thin cricothyroid membrane in adult patients compared to pediatric patients. Anatomic factors in young infants such as a small cricothyroid membrane, which also has a different orientation than in adults, limits the size of a device that may be safely passed with minimal damage to the larynx (12,15–17). Furthermore, the hyoid bone and cricoid cartilage are often more prominent than the thyroid cartilage, making identification of anatomical landmarks and
relational anatomy more difficult to appreciate (12). This makes cricothyrotomy in young children technically more challenging, if not contraindicated, even in the hands of the experienced practitioner. The lack of availability of commercial cricothyrotomy kits for this age group, along with these age-specific anatomic factors, make it difficult to perform expeditious placement of a cricothyrotomy (12,17).

A supraglottic airway device can be used as a rescue airway for oxygenation and ventilation when traditional bag mask ventilation or tracheal intubation is difficult to perform (4,18). In pediatric patients, the most widely used and researched supraglottic airway for airway rescue is the cLMA (19,20). The proseal LMA (pLMA) is another supraglottic airway device used for airway rescue. This device incorporates the provision of an esophageal drain tube along with a larger mask bowl compared to the cLMA. Both the cLMA and the pLMA can be used as a conduit for tracheal intubation, but both are limited by the size of ETT that will fit the lumen, especially when using a cuffed ETT (6,21). Recently, a new supraglottic airway, the air-Q ILA, has been introduced into pediatric airway practice. It is available as a reusable device from size 2.0 to 4.5, and as a disposable device from size 1.0 to 4.5. The main features of the air-Q ILA are described in Figure 1.

Blind tracheal intubation through the air-Q ILA is conceptually identical to using the ILMA and involves the following steps: 1) the air-Q ILA is deflated and inserted using a rotational technique (Figure 2, A and B); 2) the cuff of the air-Q ILA is inflated according to the manufacturer’s guidelines and ventilation is verified; 3) the air-Q ILA 15-mm airway connector is removed; 4) the ETT is reverse loaded through the lumen of the air-Q ILA into the trachea; and 5) ventilation through the ETT is verified (Figure 2, A–D). Removal of the air-Q ILA after tracheal intubation is optional and the clinician may leave the air-Q ILA in situ with the ETT. The rotational technique for inserting the air-Q ILA and the reverse loading of the ETT are illustrated and described in Figure 2, A–D.

We chose not to remove the air-Q ILA after tracheal intubation because there is always a risk of ETT dislocation or extubation upon removal of a supraglottic device. This can be a serious problem in the face of a bleeding airway, especially when the airway was initially difficult to secure. If removal is desired after successful tracheal intubation through the air-Q ILA, the device can be removed using a manufactured removal stylet (22). Alternatively, if the removal stylet is unavailable, laryngeal forceps can be used to stabilize the ETT while withdrawing the air-Q ILA in a manner similar to removing the LMA.

There are several potential advantages of using the air-Q ILA compared to the cLMA or pLMA in the context of intubation. Structurally, in contrast to the cLMA, the air-Q ILA has advantages: a wider and deeper mask bowl designed to improve airway seal and anatomical alignment; a removable 15-mm connector; a shorter and wider shaft; and no aperture bars (Figure 1). In addition, the elevated ridge around a keyhole-shaped outlet and the auxiliary
airway hole above it (Figure 1) help to prevent the epiglottis from being trapped and drawn into the ventilating orifice. These properties allow for epiglottic isolation and passage of a larger-bore ETT with a greater depth of penetration of the inserted ETT into the trachea. These design features, which aid in epiglottic isolation, may help the emergency physician when intubating through this device in younger children, in whom there is a higher incidence of epiglottic downfolding when a supraglottic airway is placed (23,24).

Lastly, mask ridges are incorporated into the front end of the mask bowl. When the bowl is inflated, these ridges move against the posterior larynx, improving the anterior mask seal. This helps isolate the esophagus, reducing the potential for aspiration.

However, like the cLMA, the air-Q ILA’s main limitation is its inability to drain stomach contents in non-fasted or full-stomach patients because there is no built-in provision for a drain tube as there is with the pLMA. Although the design features mentioned above may assist in aerodigestive separation, the manufacturers do not recommend the use of these devices for the prevention of aspiration of stomach contents. Therefore, the clinician must weigh the benefits of emergency airway needs against the potential risk of aspiration in these patients.

Both of these cases were encountered in a rural hospital setting without alternative airway equipment such as a fiberoptic bronchoscope, lighted stylet, or retrograde intubation set. Although we anticipated potential difficulty in laryngoscopy, we expected easy mask ventilation and, because the patency of both patients’ airways was unlikely to be reliant on their own muscle tone, paralysis was administered to obtain the most optimal view possible to facilitate direct laryngoscopy for RSI. We were able to place the air-Q ILA to oxygenate and ventilate, and subsequently to secure the airway with a cuffed ETT on the first attempt.
The passage of an adequately sized cuffed ETT (Table 1). May permit reasonable rescue ventilation, neither allows men of the air-Q ILA. Although the cLMA or pLMA allowed by successful blind tracheal intubation through the air-Q ILA was approximately 90% upon first pass. Further studies are necessary to confirm the success rate of tracheal intubation using the air-Q ILA, blind or laryngoscopy in two children with airway bleeding after RSI. We present two cases of failed intubation with direct laryngoscope-guided, compared to other supraglottic airway devices.

Table 1. Pediatric Sizing and a Comparison of Maximum Tracheal Tube (TT) Sizes that Will Fit Through the Air-Q ILA, the LMA-Proseal (pLMA), and the LMA-Classic (cLMA)/LMA-Unique

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<th>Air-Q</th>
<th>LMA</th>
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<th>Maximum Uncuffed TT Size (mm ID) Permitted by the pLMA</th>
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<td>20–30</td>
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<td>4.5</td>
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ID = inner diameter.

The aim of this case report was to highlight the role of the air-Q ILA as a rescue ventilatory device and as a conduit for tracheal intubation in pediatric patients after failed laryngoscopy. In our clinical experience of 50 pediatric patients, the success rate for blind tracheal intubation through the air-Q ILA was approximately 90% upon first pass. Further studies are necessary to confirm the success rate of tracheal intubation using the air-Q ILA, blind or bronchoscope-guided, compared to other supraglottic airway devices.

CONCLUSION

We present two cases of failed intubation with direct laryngoscopy in two children with airway bleeding after RSI in the ED. In each case, insertion of an air-Q ILA was followed by successful blind tracheal intubation via the lumen of the air-Q ILA. Although the cLMA or pLMA may permit reasonable rescue ventilation, neither allows the passage of an adequately sized cuffed ETT (Table 1).

REFERENCES

An update on newer pediatric supraglottic airways with recommendations for clinical use

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Keywords
airway; devices; children; laryngeal masks; supraglottic airways

Summary
Supraglottic airways are an established part of routine and emergency pediatric airway management, including use in difficult airways and neonatal resuscitation. With the introduction of newer supraglottic airways in children, efficacy can only be determined by comparing these devices with those that are already well established (laryngeal mask airway Classic and laryngeal mask airway ProSeal). This narrative review aims to present the current literature on these newer supraglottic airways and give recommendations for their use in various clinical scenarios based on the existing evidence.

Introduction
Supraglottic airways (SGAs) may be pragmatically defined as a device that facilitates oxygenation and ventilation while sitting immediately outside the larynx to form a perimembranous seal. SGAs are an established part of routine and emergency pediatric airway management, including use in the difficult airway and neonatal resuscitation.

Supraglottic airways may be classified as first- or second-generation devices based on the presence of a gastric access channel (1). First-generation devices are simple airway tubes attached to a mask that rests over the glottic opening. Second-generation devices incorporate a gastric access channel that allows for gastric ventilating and the option to place a gastric tube. Correct placement of an SGA results in the leading edge of the device to rest in the upper esophagus, creating a ‘second seal’ or hypopharyngeal seal. Second-generation devices typically provide a better ‘second seal’ which can support higher airway pressures than first-generation devices. The improved airway seal with the added gastric access channel helps reduce the risk of gastric insufflation, allows for more effective positive pressure ventilation (PPV), and offers some protection against unexpected regurgitation and aspiration (2,3).

Since the introduction of the first SGA 30 years ago, many variations of new first- and second-generation devices have been designed to improve ease of insertion, PPV, and facilitate tracheal intubation. This review aims to briefly present the evidence surrounding the use of established pediatric first- and second-generation SGAs: the laryngeal mask airway Classic, laryngeal mask airway Unique, and laryngeal mask airway ProSeal, which were introduced into clinical practice in 1987, 1997, and 2000, respectively; and to provide a more detailed critique of newer pediatric SGAs: the air-Q, laryngeal mask airway Supreme, i-gel, and Ambu Aura-i, which have the most evidence to support their use in the pediatric population. In addition, this review of the current literature will also provide a summary of recommendations for the use of these newer SGAs in clinical practice. Safety data are difficult to acquire and require extensive use of these devices in thousands of patients, which may bias clinicians against newer devices. As a result,
establishing safety data on newer SGAs can only be obtained over time as the use of these devices becomes more commonplace.

Established SGAs (laryngeal mask airway Classic, laryngeal mask airway ProSeal, laryngeal mask airway Unique): a brief overview

The laryngeal mask airway Classic is a first-generation device without a gastric access channel and is widely used in pediatric anesthesia. The laryngeal mask airway Classic has been shown to be superior to mask ventilation, even when used by inexperienced clinicians (4–7). The hemodynamic stress response associated with laryngeal mask airway insertion is less than that with laryngoscopy and tracheal intubation, and comparable to the insertion of an oral airway (7–10). In routine airway management by inexperienced personnel, the laryngeal mask airway Classic can be faster and easier to insert than a tracheal tube (TT) (4). However, increased technical difficulties and airway complications are noted with decreasing patient age (11,12). Complications include mask displacement, poor airway seal, gastric insufflation, and reflex activation of the airway (13). Despite these areas of concern, the laryngeal mask airway Classic has been safely utilized in pediatric practice.

The laryngeal mask airway Classic is constructed of silicone and designed to be reused up to 40 times. Despite proper sterilization, the risk of infection can remain because autoclaving fails to completely remove prions and protein deposits (14). An evaluation of 50 previously used and sterilized laryngeal mask airway Classics revealed residual protein after one use and increased protein load with each subsequent use (15).

The laryngeal mask airway Unique is a disposable version of the laryngeal mask airway Classic, made of polyvinylchloride (PVC) or silicone (in some countries), and was introduced in 1997. The laryngeal mask airway Unique performs similar to or better than the laryngeal mask airway Classic (16,17). The ease of insertion, combined with a disposable design, may potentially make the laryngeal mask airway Unique a good device for novice users and in out-of-hospital settings.

The laryngeal mask airway ProSeal is a reusable second-generation device that was introduced in 2000. Pediatric-sized laryngeal mask airway ProSeals (1.0–2.5) became available in 2004. In addition to the gastric channel, there is a built-in bite block to prevent airway obstruction. A deep mask bowl improves the hypopharyngeal seal, which facilitates PPV. Compared with the laryngeal mask airway Classic, the laryngeal mask airway ProSeal has the same (18) or better (19) airway leak pressures with decreased rates of gastric insufflation (2,18–24). Higher first-attempt insertion rates and higher leak pressures were also seen in neonatal resuscitation studies utilizing manikins with the laryngeal mask airway ProSeal when compared with the laryngeal mask airway Classic (25,26). The laryngeal mask airway ProSeal has been shown in a variety of clinical trials to outperform the laryngeal mask airway Classic, and can be an effective means for mechanical ventilation (2,18,20,22,23,27,28).

Key concepts

The airway seal of various first-generation SGAs and their leak volumes are largely dependent on the inflation status of the cuff, which has been shown to be less than the usual recommended range (<60 cmH2O), for optimal performance (29–31). Lower cuff pressures have also been shown to be beneficial with the laryngeal mask airway Supreme (32). However, there is insufficient evidence to definitively recommend the best cuff pressure for optimal clinical performance with second-generation SGAs. Based on these studies, it is conceivable that a lower cuff pressure for newer SGA devices may be better for optimal sealing characteristics. In addition, the anatomic positioning of smaller sized SGAs does not necessarily correlate with the functionality of the SGA, and ventilation can be effective, despite significant downfolding of the epiglottis on fiberoptic examination (33,34). This is also true with the newer SGAs (35–38).

Both the laryngeal mask airway Classic and the laryngeal mask airway ProSeal have a strong evidence base supporting their use in children. Therefore, newer SGAs should be compared with these established standards when evaluating their efficacy (1).

Newer SGAs

First-generation devices

air-Q

The air-Q is an oval-shaped laryngeal mask with a shortened, wide, curved airway tube. The air-Q mask contains an elevated keyhole-shaped ventilating orifice designed to prevent epiglottic downfolding (Figure 1); however, epiglottic downfolding can still occur in smaller children (37,39).

The air-Q has three versions, and is manufactured as a reusable or single-use device:

1. Standard cuffed
2. Self-pressurized (air-Q SP; lack of an inflatable cuff)
3. air-Q with an esophageal blocker: a second-generation device which allows for evacuation of gastric contents; not yet available for children.
The air-Q SP performed well in a large observational study of several infants and small children (40). A randomized trial of children weighing 10–15 kg found higher airway leak pressures when the cuffed air-Q was used for routine anesthetic maintenance, as compared with the laryngeal mask airway Unique (35). The air-Q was also reported to have superior fiberoptic views of the larynx. Another randomized trial compared the air-Q SP with the laryngeal mask airway Unique in older children. The two devices performed similarly in terms of airway leak pressure, fiberoptic views, and complication rates (36). The cuffed air-Q was shown to be associated with higher airway leak pressures and superior fiberoptic views when compared with the flexible laryngeal mask airway in infants weighing less than 10 kg (41). Various studies have reported that leak pressures with the air-Q are similar (36) or higher (35) than the laryngeal mask airway Unique, but lower than the laryngeal mask airway ProSeal (42).

In addition to its use in routine anesthetic maintenance, the air-Q was also designed to assist tracheal intubation in both infants and children (37,39,43). Several reports suggest that the air-Q does offer advantages over traditional laryngeal masks and the Ambu Aura-i when used as a conduit for fiberoptic-guided tracheal intubation in children (39,41,44). Compared with the Ambu Aura-i, both devices performed well as conduits for tracheal intubation including similar success rates, time to tracheal intubation, and fiberoptic views (39). However, the utility of the Ambu Aura-i size 1.5 with cuffed TT was limited by its narrower airway tube, which could not accommodate the passage of the TT pilot balloons. The air-Q design has a shorter, wider airway tube to facilitate passage of cuffed TTs and subsequent removal of the air-Q after tracheal intubation (37,39). The largest TT that can be accommodated by the air-Q is printed on the dorsal aspect of the airway tube. The removal process has been shown to be effective with low risk for inadvertent tracheal extubation when a removal stylet is used to stabilize the TT during air-Q removal (37,39,43,44).

The air-Q may be a useful tool in small children, as it was shown to require fewer maneuvers to optimize the fiberoptic glottic view for tracheal intubation when compared with a traditional free-handed fiberoptic intubation in children with normal airways (45). The air-Q has also been used successfully in children with anticipated and unanticipated difficult airways (46–53), while allowing for the use of cuffed TTs. A retrospective evaluation of anticipated and unanticipated difficult airways found that the air-Q was used successfully as a conduit for intubation in all cases (47). A case series showed that in children with craniofacial abnormalities (limited mouth opening), the air-Q provided adequate ventilation even when downsized, and was still an effective conduit for fiberoptic-guided tracheal intubation with an appropriately sized cuffed TT (44). This ability to facilitate tracheal intubation with larger cuffed TT even with a smaller air-Q may be an advantage over the laryngeal mask airway Classic. The air-Q has also been used to successfully relieve upper airway obstruction during rapid sequence fiberoptic intubations (53) as well as facilitate oxygenation while performing fiberoptic tracheal intubations in children with predicted difficult airways (44,47,49,53).

In addition, the air-Q may prove to be beneficial in neonatal resuscitation. In a neonatal manikin resuscitation study, novices found the air-Q easier to use than the Soft Seal laryngeal mask for emergency airway management during chest compression (54). Table 1 summarizes the studies performed with the air-Q in children.

**Second-generation devices**

The most established second-generation device is the laryngeal mask airway ProSeal, and it is associated with a long history of safety and efficacy for various procedures in children (1,55). Newer second-generation devices include the laryngeal mask airway Supreme and the i-gel. A recent survey of 240 anesthetists in the United Kingdom showed that adoption of second-generation devices for use in children has been slow, with 88% preferentially using first-generation devices (56) and citing safety concerns as the determining factor. The choice of SGA was also largely influenced by departmental preference and personal choice.
**Laryngeal mask airway Supreme**

The laryngeal mask airway Supreme is a single-use, second-generation device made of PVC. It was designed to combine features of the laryngeal mask airway ProSeal (gastric access and high airway leak pressures) and the laryngeal mask airway Fastrach (curved, rigid airway to facilitate easy insertion). The airway tube of the laryngeal mask airway Supreme also incorporates a bite block at its proximal end, and has a drain tube that travels through the center of the device and exits out of the leading edge of the mask (Figure 1). The ventilating orifices are located on either side of the mask bowl with overlying epiglottic fins to prevent epiglottic trapping. The proximal portion of the laryngeal mask airway Supreme mask is also relatively larger than the laryngeal mask airway ProSeal.

The laryngeal mask airway Supreme has been evaluated in a number of studies performed in children. These are summarized in Table 2. Several randomized trials comparing the laryngeal mask airway Supreme with the laryngeal mask airway Unique have shown that the laryngeal mask airway Supreme provided good gastric access, and had reduced rates of gastric insufflation with similar (32) or higher airway leak pressures (57). Compared to the i-gel, the laryngeal mask airway Supreme was shown to have lower airway leak pressures (58). However, no differences in the overall clinical performance were noted, including the ability to provide PPV. In a study simulating a difficult airway scenario, the laryngeal mask airway Supreme was associated with higher airway leak pressures than the i-gel. The laryngeal mask airway Supreme was also associated with higher first-attempt success rates and faster times for successful insertion (59). A study comparing the laryngeal mask airway Supreme with the laryngeal mask airway ProSeal showed the laryngeal mask airway Supreme to be easier to insert, and associated with less pharyngeal injury (60). In addition, another study comparing the laryngeal mask airway Supreme with the Ambu Aura-i showed lower airway leak pressures (52). In summary, the laryngeal mask airway Supreme has been shown to be a useful and effective supraglottic airway device in children.

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**Table 1** Summary of studies performed on the pediatric air-Q

<table>
<thead>
<tr>
<th>Author</th>
<th>Study population; device size(s)</th>
<th>Type of study; device(s)</th>
<th>Primary findings</th>
<th>Secondary findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jagannathan et al. (40)</td>
<td>352 children; 69 infants; all pediatric sizes</td>
<td>Observational: air-Q SP</td>
<td>99% insertion success rate</td>
<td>No difference in complication rates in infants vs older children</td>
</tr>
<tr>
<td>Whyte et al. (42)</td>
<td>110 infants and children; all pediatric sizes</td>
<td>Observational: air-Q cuffed</td>
<td>Ventilation was adequate in 108 of 110 cases</td>
<td>Fiberoptic view of the vocal cords was obtained in 102 of 110 cases</td>
</tr>
<tr>
<td>Komasawa et al. (54)</td>
<td>24 novice doctors on a neonatal manikin</td>
<td>Observational: air-Q Soft Seal laryngeal mask airway</td>
<td>Insertion time during chest compressions was faster with the air-Q than the Soft Seal ($P &lt; 0.05$)</td>
<td>n/a</td>
</tr>
<tr>
<td>Sinha et al. (43)</td>
<td>20 infants; sizes 1.0, 1.5</td>
<td>Observational: air-Q cuffed for tracheal intubation</td>
<td>Tracheal intubation successful in 19 of 20 patients</td>
<td>Mean time to device insertion was 13 s; mean time to intubation was 96 s</td>
</tr>
<tr>
<td>Jagannathan et al. (35)</td>
<td>50 children; sizes 1.5, 2.0</td>
<td>RCT (crossover design): air-Q vs laryngeal mask airway Unique</td>
<td>Mean leak pressure was higher with the air-Q: 19 vs 16 cmH$_2$O ($P = 0.01$)</td>
<td>Better fiberoptic views of glottis with air-Q</td>
</tr>
<tr>
<td>Jagannathan et al. (36)</td>
<td>60 children; size 2.0</td>
<td>RCT: air-Q SP vs laryngeal mask airway Unique</td>
<td>No difference in initial leak pressure and leak pressure measured at 10 min</td>
<td>Median time to successful insertion was faster with the air-Q SP: 12 vs 14 s ($P = 0.05$); no differences in fiberoptic view of glottis and complication rates</td>
</tr>
<tr>
<td>Jagannathan et al. (39)</td>
<td>120 infants and children; sizes 1.5, 2.0</td>
<td>RCT: air-Q vs Ambu Aura-i for tracheal intubation</td>
<td>No differences in time to tracheal intubation or overall intubation success</td>
<td>Mean leak pressure was higher with air-Q in infants; pilot balloon could not pass through the size 1.5 Ambu Aura-i</td>
</tr>
<tr>
<td>Darlong et al. (41)</td>
<td>50 infants weighing less than 10 kg</td>
<td>RCT: air-Q vs Flexible laryngeal mask airway</td>
<td>Mean leak pressure was higher with the air-Q: 21 vs 17 cmH$_2$O ($P = 0.02$)</td>
<td>Better fiberoptic views of glottis with air-Q (good view in 84% vs 48% ($P = 0.0016$)</td>
</tr>
</tbody>
</table>

RCT, randomized clinical trial.
The laryngeal mask airway Supreme has also performed well as a resuscitation device in neonates. One study utilizing neonatal manikin models demonstrated faster insertion times and higher airway leak pressures with the laryngeal mask airway Supreme when compared with the laryngeal mask airway Classic and laryngeal mask airway ProSeal (63).

**i-gel**
The i-gel is a single-use, second-generation SGA that contains a noninflatable laryngeal mask made of a gel-like thermoplastic elastomer. The semi-rigid cuff does not show any differences in airway leak pressures, or the overall clinical performance of either device (61). Some studies have also demonstrated that the laryngeal mask airway Supreme is faster to insert than the laryngeal mask airway ProSeal (60,62).

**Table 2** Summary of studies performed on the pediatric laryngeal mask airway Supreme

<table>
<thead>
<tr>
<th>Author</th>
<th>Study population; device size(s)</th>
<th>Type of study: device(s)</th>
<th>Primary outcome</th>
<th>Secondary outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trevisanuto et al. (63)</td>
<td>40 clinicians Neonatal manikin</td>
<td>Observational: laryngeal mask airway Supreme laryngeal mask airway ProSeal laryngeal mask airway Classic</td>
<td>Maximal inflation pressure and quality perceived by the operator are higher with Supreme than with laryngeal mask airway Classic and laryngeal mask airway ProSeal</td>
<td>Time to effective ventilation with the laryngeal mask airway Supreme is superior to laryngeal mask airway ProSeal</td>
</tr>
<tr>
<td>Jagannathan et al. (88)</td>
<td>100 patients; sizes 1.0, 2.0, 3.0</td>
<td>Observational: laryngeal mask airway Supreme</td>
<td>First-time insertion success rate was 97%; overall insertion success rate of 100%</td>
<td>Gastric tube placement was possible in 98% of patients; mean leak pressure was 22 cmH₂O</td>
</tr>
<tr>
<td>Jagannathan et al. (57)</td>
<td>50 patients; size 2 device</td>
<td>RCT: laryngeal mask airway Supreme laryngeal mask airway Unique</td>
<td>Median leak pressure was higher with laryngeal mask airway Supreme: 20 vs 15 cmH₂O (P = 0.01)</td>
<td>Laryngeal mask airway Unique was faster to insert; less gastric insufflation with laryngeal mask airway Supreme</td>
</tr>
<tr>
<td>Jagannathan et al. (61)</td>
<td>60 patients; size 2.0</td>
<td>RCT: laryngeal mask airway Supreme laryngeal mask airway ProSeal</td>
<td>No difference in median leak pressure: 19 vs 18 cmH₂O</td>
<td>No differences in ease and success of insertion, fiberoptic views, or complication rates</td>
</tr>
<tr>
<td>Jagannathan et al. (58)</td>
<td>168 patients; sizes 1.5, 2.0, 2.5</td>
<td>RCT: laryngeal mask airway Supreme i-gel</td>
<td>Mean leak pressure was higher with i-gel 20 vs 17 cmH₂O (P = 0.001)</td>
<td>The i-gel required a greater number of airway manipulations to maintain a patent airway</td>
</tr>
<tr>
<td>Jagannathan et al. (31)</td>
<td>180 patients; sizes 1.5, 2.0, 2.5</td>
<td>RCT: laryngeal mask airway Supreme laryngeal mask airway Unique</td>
<td>No differences in leak pressure between devices at an intracuff pressure of 40 cmH₂O vs 60 cmH₂O</td>
<td>Less rates of gastric insufflation with the laryngeal mask airway Supreme during positive pressure ventilation</td>
</tr>
<tr>
<td>Kus et al. (59)</td>
<td>60 patients with simulated difficult airway; size 2.0</td>
<td>RCT: laryngeal mask airway Supreme i-gel</td>
<td>Mean leak pressure was higher with laryngeal mask airway Supreme: 21 vs 19 cmH₂O (P = 0.019)</td>
<td>Laryngeal mask airway Supreme was faster to insert with higher success rate in simulated difficult airway scenario</td>
</tr>
<tr>
<td>Aydogmus et al. (60)</td>
<td>80 patients; size 3.0</td>
<td>RCT: laryngeal mask airway Supreme laryngeal mask airway ProSeal</td>
<td>Blood staining on removal of device was higher with the ProSeal: 10 vs 3 (P = 0.034) and associated with pharyngeal injury</td>
<td>Laryngeal mask airway Supreme was faster to insert</td>
</tr>
<tr>
<td>Hosten et al. (62)</td>
<td>60 patients; size 2.0</td>
<td>RCT: laryngeal mask airway Supreme laryngeal mask airway ProSeal</td>
<td>No difference in leak pressure between devices</td>
<td>Laryngeal mask airway Supreme was faster to insert with no difference in overall insertion success rates between devices</td>
</tr>
</tbody>
</table>

RCT, randomized clinical trial.
not require or allow for inflation or adjustment of intra-cuff pressures. Instead, the airway seal is designed to improve as the device warms to body temperature. The noninflatable cuff design has the potential advantage of faster insertion time and reduced morbidity related to cuff hyperinflation (64). Easy and rapid insertion of an SGA may be especially important for emergency situations, difficult airways, or out-of-hospital scenarios. Additional features of the i-gel include a built-in bite block, an epiglottic rest to prevent downfolding, and a gastric access channel (size 1 has no gastric channel) (Figure 1).

Among the newer SGAs, the i-gel has the greatest evidence base, and several observational, randomized studies and meta-analyses evaluating the performance of the i-gel in children are summarized in Tables 3 and 4. An observational study on older children (65) found that the i-gel was easy to insert, and had a mean airway leak pressure of 25 cmH$_2$O. Studies show similar (66) or higher (67–69) leak pressures to the laryngeal mask airway ProSeal, and higher leak pressures when compared with the laryngeal mask airway Supreme (59) or laryngeal mask airway Classic (67,68). Two studies demonstrated no difference in the airway leak pressures between the laryngeal mask airway Classic and i-gel, but found that the i-gel was faster (64) and easier (70) to insert in infants, a population historically at higher risk for mask displacement during anesthetic maintenance with the laryngeal mask airway Classic.

Compared with the Ambu AuraOnce, the i-gel was associated with higher airway leak pressures, longer insertion times (71), and a tendency to slide out of the mouth after insertion. Spontaneous dislodgement of the i-gel was noted by several authors (58,71–73), and may be attributed to a relatively wider conical mask compared with other traditionally designed laryngeal masks. Although the design of the i-gel includes an elliptically shaped tube to prevent axial rotation and increase stability, it has been reported to require positional adjustments during the anesthetic course to maintain airway patency (61). These adjustments were more common when the i-gel was used in smaller children. There was an observed outward displacement of the i-gel that often necessitated downward traction and fixation with tape to maintain a good airway seal (71). Two recent meta-analyses (38,76) included nine RCTs comparing the i-gel with various SGAs in children. The i-gel was found to have higher airway leak pressures and superior fiberoptic views compared with other SGAs in children, including the laryngeal mask airway ProSeal. However, there were no differences between the SGAs in terms of rates of successful insertion, insertion times, or overall complications. Higher airway leak pressures may be clinically advantageous in settings requiring increased ventilating pressures such as prone positioning, obesity, and lung disease. Table 4 summarizes the RCTs performed on the i-gel.

**Supraglottic airways as conduits for tracheal intubation**

Supraglottic airways are ideal conduits for tracheal intubation in children who cannot be intubated by direct laryngoscopy, and are recommended in difficult airway algorithms (76,77). Advantages include the option for continuous oxygenation during intubation, hands-free operation, and relief of upper airway obstruction in children with difficult airways (53,79,80). Evidence for the

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**Table 3** Summary of observational trials with the pediatric i-gel

<table>
<thead>
<tr>
<th>Author</th>
<th>Study population; device size(s)</th>
<th>Primary findings</th>
<th>Secondary findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beringer et al. (72)</td>
<td>120 children; sizes 1.5, 2.0, 2.5</td>
<td>Median insertion time was 14 s. Manual ventilation was possible in all cases.</td>
<td>Fiberoptic inspection through the i-gel revealed a clear view of the vocal cords in 40 of 48 cases (87%)</td>
</tr>
<tr>
<td>Abukawa et al. (89)</td>
<td>70 children; sizes 1.5, 2.0, 2.5</td>
<td>Overall first-attempt success rate was 94%. Gastric tube insertions were easy in all patients. The overall mean leak pressure was 23 cmH$_2$O.</td>
<td>Complication rates were higher in size 1.5 group</td>
</tr>
<tr>
<td>Hughes et al. (73)</td>
<td>154 children; sizes 1.2, 2.0, 2.5</td>
<td>First insertion attempt was successful in 93.5% of patients. Gastric tube placement was successful in 90% of cases. Minor complications occurred in 20% of cases.</td>
<td>Considerable vigilance is required when securing the device</td>
</tr>
<tr>
<td>Beylacq et al. (65)</td>
<td>50 children; size 3.0</td>
<td>Overall first-attempt success rate was 100%. The mean seal pressure was 25 cmH$_2$O.</td>
<td>There was no gastric insufflation. Gastric tube insertion was achieved in all cases</td>
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</table>

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passing an exchange catheter through the SGA with subsequent removal, followed by insertion of the TT over the exchange catheter, with or without a guidewire (83). Another potential advantage of the SGAs (air-Q) with larger diameter airway tubes is the ability to directly pass a cuffed TT through the device, thus avoiding an additional step and the need for an intubation introducer (53).

**Recommendations for clinical use**

While the older SGAs have the largest evidence base and are already established in pediatric use, the availability of high-quality data on newer SGA devices suggests the potential benefit of a specific device in certain clinical situations. While the choice of the device used should ultimately be based on experienced clinical judgment, the authors have the following recommendations for the clinical use of newer pediatric SGAs.

**Spontaneous ventilation**

The existing data suggest that the use of the laryngeal mask airway ProSeal, laryngeal mask airway Supreme, air-Q, and i-gel for spontaneous ventilation in small infants is not associated with the same increased risk for complications as seen with the laryngeal mask airway Classic. However, due to limited number of studies in infants, there is insufficient evidence to recommend one SGA over another in spontaneously ventilating patients. In older children, the evidence base is larger, and all newer SGAs have demonstrated successful efficacy. Therefore, in children, the clinician should choose the device with which he/she has adequate experience.

**Positive pressure ventilation**

Supraglottic airway use in PPV must take into account higher airway pressures and associated risks for gastric insufflation and aspiration. The air-Q and Ambu Aura-i are both first-generation devices with similar or lower leak pressures compared with the laryngeal mask airway ProSeal, and therefore offer no significant advantage in the setting of PPV for routine anesthesia. The i-gel may be a useful alternative to the laryngeal mask airway ProSeal for PPV, as they both have comparable leak pressures and gastric access capabilities. The i-gel has the added advantage over the laryngeal mask airway ProSeal in that it is disposable and therefore has lower risk for infection transmission. The laryngeal mask airway Supreme has been shown to provide effective PPV as well, but more widespread use of this device is needed to make definitive conclusions.

**Pediatric/neonatal resuscitation**

Insufficient evidence exists to recommend the use of a specific SGA in the setting of pediatric cardiac arrest. Further studies are necessary to compare the advantages and limitations of SGAs over conventional methods currently used in pediatric resuscitation.

Supraglottic airways may also be used to provide ventilation in neonates when bag-mask ventilation and intubation have failed. The American Heart Association and the European Resuscitation Council’s incorporation of SGAs into the guidelines for neonatal resuscitation reflects support for this use. In addition, studies have shown that initial resuscitation with an SGA is both feasible and safe (5,25,26,84–87). Some studies appear to show some advantage to using an SGA over tracheal intubation during neonatal resuscitation, including lower rates of failure, and reduced time to secure the airway (5). Even though newer devices have been shown to be useful, there is insufficient evidence to recommend a particular device at this time.

**Emergent airway management**

Although tracheal intubation is the preferred method for establishing an airway in emergent situations, SGAs may be used when tracheal intubation may be difficult to perform, such as out-of-hospital emergencies or interhospital transport. SGAs are relatively easy to insert blindly, and may provide improved ventilation compared to bag-mask ventilation by inexperienced personnel, which could be a useful intermediate step until a definitive airway can be secured. Second-generation devices may have the added benefit by allowing drainage of gastric contents. However, there is not enough evi-
successful use of SGAs in difficult airway scenarios is based on reports from case series and observational studies (80).

Two new SGAs specifically designed to facilitate tracheal intubation are the air-Q (discussed earlier) and the Ambu Aura-i. The Ambu Aura-i is a newer model of the Ambu AuraOnce, and is specifically designed for tracheal intubation with fiberoptic guidance in children. The mask bowl of both of these devices resembles the laryngeal mask airway Classic, but without aperture bars (Figure 1). The airway tube has a 90° angle for easy insertion. Compared to the i-gel and air-Q, the Ambu AuraOnce offers similar fiberoptic views of the glottis (39,71), although it should be noted that the Ambu Aura-i size 1.0 and 1.5 does not permit the passage of cuffed tube. A study evaluating the use of SGAs as a conduit for diagnostic and therapeutic bronchoscopy found that PVC-based devices, including the Aura Once, were associated with more resistance during bronchoscope manipulation than silicone-based SGAs (81).

The i-gel offers equal or better fiberoptic views of the glottis compared with the laryngeal mask airway Classic or laryngeal mask airway ProSeal (64,66,82). The favorable fiberoptic views may suggest a role for the i-gel as a conduit for tracheal intubation; however, no formal pediatric study has been performed to date.

The laryngeal mask airway ProSeal and laryngeal mask airway Supreme may be used as conduits for tracheal intubation, but their narrower airway tubes preclude the ability to directly pass an adequately sized TT through these devices. Therefore, the use of an airway exchange catheter, an intubation introducer (Aintree exchange catheter: for size 3 and larger), or a guidewire technique is required. A two-step technique involves first

<table>
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<th>Table 4 Summary of randomized trials with the pediatric i-gel</th>
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<td>Theiler et al. (71)</td>
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<tr>
<td>Goyal et al. (67)</td>
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<td>Das et al. (69)</td>
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<tr>
<td>Mitra et al. (68)</td>
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<td>Lee et al. (64)</td>
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<td>Gasteiger et al. (66)</td>
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<td>Fukuhara et al. (82)</td>
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<td>Jagannathan et al. (58)</td>
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<td>Kim et al. (70)</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Devices</th>
<th>Approximate cost per single unit (US dollars)</th>
<th>Pediatric sizes; recommended weight range</th>
<th>First or second generation</th>
<th>Ease of insertion: first-attempt insertion rate; overall insertion success rate</th>
<th>Leak pressures (reported range) (cmH₂O)</th>
<th>Use as a conduit for fiberoptic (FO)-guided tracheal intubation</th>
<th>Areas of potential concern</th>
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<tbody>
<tr>
<td><strong>Established SGAs</strong></td>
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<tr>
<td>Laryngeal mask airway Classic</td>
<td>$80-200 (reusable up to 40 use)</td>
<td>1.0: &lt;5 kg</td>
<td>First</td>
<td>91% (first attempt) 99–100% (overall)</td>
<td>15–23</td>
<td>Most widely used for fiberoptic intubation; may be difficult to remove when cuffed tracheal tubes (TT) are utilized</td>
<td>Higher complication rate and lower leak pressures in small infants; potential for gastric insufflation</td>
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<td>1.5: 5–10 kg</td>
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<td>2.0: 10–20 kg</td>
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<td>Laryngeal mask airway Unique</td>
<td>$7–10 Single use</td>
<td>1.0: &lt;5 kg</td>
<td>First</td>
<td>89% (first attempt) 100% (overall)</td>
<td>15–18</td>
<td>No formal studies evaluating use as a conduit for tracheal intubation; FO views inferior to air-Q</td>
<td>Potential for gastric insufflation</td>
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<td></td>
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<td>1.5: 5–10 kg</td>
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<tr>
<td>Laryngeal mask airway ProSeal</td>
<td>$100-250 (reusable up to 40 use)</td>
<td>1.0: &lt;5 kg</td>
<td>Second</td>
<td>94% (first attempt) 75% (overall)</td>
<td>22–23</td>
<td>Requires two-step technique for larger TTs</td>
<td>Size 1.5 associated with difficult insertion; narrow airway tube requires smaller TT or exchange catheter technique</td>
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<td></td>
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<td>1.5: 5–10 kg</td>
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<td><strong>Newer SGAs</strong></td>
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<tr>
<td>air-Q</td>
<td>$7–10 Single use</td>
<td>0.5: &lt;4 kg</td>
<td>First</td>
<td>99% (first attempt) 99–100% (overall)</td>
<td>19–25</td>
<td>High success rates and accommodates cuffed TTs; FO views superior to laryngeal mask airway Unique</td>
<td>Potential for gastric insufflation</td>
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<td>1.0: 4–7 kg</td>
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<td>1.5: 7–17 kg</td>
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<tr>
<td>Ambu Aura-i</td>
<td>$5–8 Single use</td>
<td>1.0: &lt;5 kg</td>
<td>First</td>
<td>93% (first attempt) 98% (overall)</td>
<td>16–22</td>
<td>High success rate; FO views similar to air-Q and i-gel</td>
<td>Size 1 and 1.5 cannot accommodate pilot balloon of cuffed TTs; potential for gastric insufflation</td>
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<td>1.5: 5–10 kg</td>
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<td>3.0: 30–50 kg</td>
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<tr>
<td>Laryngeal mask airway Supreme</td>
<td>$10–20 Single use</td>
<td>1.0: &lt;5 kg</td>
<td>Second</td>
<td>97% (first attempt) 100% (overall)</td>
<td>17–20</td>
<td>No formal studies evaluating use as a conduit for tracheal intubulation; requires two-step technique for larger TTs; similar FO view compared with laryngeal mask airway ProSeal</td>
<td>Narrow airway tube requires smaller TT or exchange catheter technique</td>
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<td>3.0: 30–50 kg</td>
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<tr>
<td>i-gel</td>
<td>$10–20 Single use</td>
<td>1.0: 2–5 kg</td>
<td>Second</td>
<td>91% (first attempt) 93% (overall)</td>
<td>20–27</td>
<td>No formal studies evaluating use as a conduit for tracheal intubulation; superior FO view compared with laryngeal mask airway Classic and laryngeal mask airway ProSeal</td>
<td>Spontaneous dislodgement observed in smaller sizes; size 1.0 lacks gastric access</td>
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<td></td>
<td></td>
<td>1.5: 5–12 kg</td>
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<td>2.5: 25–35 kg</td>
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<td>3.0: 30–60 kg</td>
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FO, fiberoptic; TT, tracheal tube.

*a*Reflects approximate cost in US dollars per single device. Cost may differ depending on distributor and country.
dence to suggest the use of a particular device in such emergency situations.

Conclusion

A variety of new SGAs for use in children have emerged since their introduction into clinical practice over 30 years ago. As new devices are introduced into clinical practice, assessing the potential advantages and limitations of each device through thorough clinical evaluations remains important. Table 5 summarizes the SGAs discussed and outlines potential areas of concern.

Despite the many new devices, the laryngeal mask airway Classic, laryngeal mask airway ProSeal, and laryngeal mask airway Unique remain the most ubiquitous devices in pediatric use, and still provide excellent conditions in a wide variety of situations with only a few specific exceptions. For healthy children undergoing routine anesthesia with spontaneous ventilation, the laryngeal mask airway Classic and laryngeal mask airway Unique are suitable devices, except in infants where the laryngeal mask airway ProSeal, air-Q, or i-gel may be preferable for their relative stability during anesthetic maintenance. For PPV, the best options are either the established laryngeal mask airway ProSeal or the newer i-gel for their higher airway leak pressures, and gastric access. When used as a conduit for tracheal intubation, the air-Q and Ambu Aura-i were designed for this purpose and may better facilitate the tracheal intubation and device removal process when compared with the laryngeal mask airway Classic. For use in emergency situations such as failed intubation and cardiac arrest, a lack of data suggests that pragmatic choices must be made, as both established and newer devices have all been used successfully.

Acknowledgments

This research was carried out without funding.

Conflict of interest

No conflicts of interest declared.

References

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24 Karippacheril JG, Varghese E. Crossover comparison of airway sealing pressures of 1.5


56 Trevisanuto D, Parotto M, Doglioni N et al. The Supreme Laryngeal Mask Airway

N. Jagannathan et al.
Newer supraglottic airways for children

Pediatric Air-Q ILA Is an Effective Primary Airway Device


The air-Q ILA was effective and easy to use in this healthy pediatric population.

The air-Q® is a single-use intubating laryngeal airway (ILA). To determine its operating characteristics in children, researchers evaluated insertion of weight-appropriate devices in 110 healthy children (weight <50 kg) undergoing elective surgery. Oropharyngeal leak pressures and tidal volumes were measured with the head in five positions: neutral, maximum flexion, maximum extension, and 90 degrees to the left and right. Three anesthesiologists performed all insertions. Devices were provided by the manufacturer.

All insertions were considered easy and all were successful: 98% on the first attempt and 2% on the second attempt. Median oropharyngeal leak pressures in the neutral-head position ranged from 14 to 23 mm H2O and increased with head flexion for all device sizes. Median tidal volumes did not differ with head position. For all device sizes, ventilation was adequate (chest rise with or without audible leak) in 98% of insertions. On evaluation with a fiberoptic laryngoscope, vocal cords were visible in 93% of children. The air-Q ILA was removed prematurely in 6 patients because of low seal pressure, gastric insufflation, hypoxia that was subsequently determined to be from a cardiac shunt, and an unknown reason. Gastric insufflation occurred with 10% of insertions and minor mucosal injury with 5% of insertions.

Comment

The air-Q ILA was effective and easy to use in this healthy pediatric population and is a reasonable choice for a primary or backup airway management for children with normal airways. The easy visibility by fiberoptic laryngoscopy suggests a high likelihood of successful intubation through the device.

Editor Disclosures at Time of Publication

Citation(s):
Product Study: air-Q

The air-Q intubating laryngeal airway is a supraglottic airway device which may overcome some limitations inherent to the classic laryngeal mask airway for tracheal intubation. The authors of a study published in Pediatric Anesthesia reported on a series of cases with patients with anticipated difficult airway in whom the air-Q device was used successfully as a conduit for fiberoptic intubation.*

Background
The laryngeal mask airway has been demonstrated to be effective as a conduit for tracheal intubation in pediatric patients with a difficult airway. Though the LMA has undergone advancements to facilitate tracheal intubation in adults, the authors note that such advancements were not previously available for application to children. The advantages of LMA-assisted tracheal intubation are ease of placement, reliable alignment of the glottic opening, the ability to continuously oxygenate and ventilate the patient, and minimizing disconnection time from the breathing circuit. The air-Q intubating laryngeal airway supraglottic airway device has been designed to overcome the limitations of classic LMA for tracheal intubation. Its advantages include: a shorter, more curved shaft, an easily removable airway adapter, lack of a grill in the ventilating orifice, and the ability to remove the laryngeal airway after tracheal intubation with or without a stabilizing rod. The authors present several cases of patients with anticipated difficult airway in whom the air-Q was successfully used as a conduit for fiberoptic intubation.

I. 2-Year Old With Hurler’s Syndrome
A 2-year-old boy with Hurler’s syndrome was to undergo ventriculo-peritoneal shunt revision. Two months before the revision, the boy had been difficult to ventilate after inhalation induction. A Cormack and Lehane Grade IV was noted upon direct laryngoscopy. A number 2 classic LMA was placed revealing a C&L II view of the glottis through a fiberoptic bronchoscope, and the patient was successfully intubated with a 4.0 uncuffed TT via the LMA. A new supraglottic revealed a limited oropharyngeal space secondary to mucopolysaccharide deposits resulting in a mouth opening of 12 mm. Intramuscular ketamine was administered, and IV access established. When positive pressure ventilation was adequate, paralysis was instituted with rocuronium. A size 1.5 air-Q ILA was inserted with a leak pressure of 24 cm H₂O followed by fiberoptic-assisted tracheal intubation with a 4.0 mm ID cuffed TT.

II. 2-Year Old With Large Bilateral Maxillomandibular Dysplastic Mass
A 2-year-old girl with a large bilateral maxillomandibular dysplastic mass presented for excision. CT scans revealed an expanding fibrous mass involving both the maxilla and the mandible. Previous records documented easy mask induction and placement of a 1.5 LMA for the CT scans. The girl’s mouth opening was now less than 2 cm. Inhalation induction was performed with sevoflurane in oxygen, and IPPV was instituted. IV access was obtained and paralysis was established with rocuronium. An air-Q ILA size 1.5 was placed with a leak pressure of 26 cm H₂O and the patient was intubated with a 4.5 ID cuffed TT over a fiberoptic scope.

III. 6-Year-Old With Treacher-Collins Syndrome
A 6-year-old boy with Treacher-Collins syndrome was to undergo dental extractions. For a previous mandibular distraction surgery, mask ventilation was noted to be easy and an oral fiberoptic intubation was successfully accomplished, although difficult secondary to a large epiglottis. Airway examination revealed a mouth opening of 8 mm with significant micrognathia. Anesthesia was the same as described above for patient II. An air-Q ILA size 1.5 was placed without difficulty, with a leak pressure of 30 cm H₂O and the patient was intubated with a 5.0 ID cuffed TT using a fiberoptic scope.

IV. 7-Year-Old With Goldenhar Syndrome
A 7-year-old boy with Goldenhar syndrome was scheduled for mandibular extraction. Prior history was significant for easy mask ventilation, but limited visualization by direct laryngoscopy and difficult tracheal intubation. Airway examination revealed a limited mouth opening of 15 mm and micrognathia. The patient was sedated with 70% nitrous oxide in oxygen and an IV was placed. Anesthetic induction was achieved with propofol. An air-Q ILA size 2 was placed with a leak pressure of 26 cm H₂O and the patient was intubated with a 5.5 ID cuffed TT and a fiberoptic scope.

V. A 16-Month-Old Girl With Hunter’s Syndrome
A 16-month-old girl with Hunter’s syndrome presented for magnetic resonance imaging of the brain and spine. At age 10 months she was found to have limited visualization upon direct laryngoscopy. She was a difficult intubation and was intubated with a fiberoptic scope with a 3.5 uncuffed TT through a no. 1.5 LMA for a ventriculo-peritoneal shunt placement. Airway examination revealed a limited oropharyngeal space due to mucopolysaccharide deposits. A size 1 air-Q ILA was placed with

*All information in this article was originally published in a different form and is from the paper "The new air-Q intubating laryngeal airway for tracheal intubation in children with anticipated difficult airway: a case series," by Narasimhan Jagannathan, MD; Andrew G. Roth, MD; Lisa E. Sohn, MD; Thomas Y. Pak, DO; Sapan Amin, MD, and Santhanam Suresh, MD, FAAP. The authors are with the Department of Pediatric Anesthesiology, Children’s Memorial Hospital, Northwestern University’s Feinberg School of Medicine, Chicago, IL. The authors thanked Dr. Daniel Cook of Cookgas, USA for his support. The original article is © 2009 The Authors, Pediatric Anesthesia 2009, © 2009 Blackwell Publishing Ltd. The paper was provided to this journal by Mercury Medical, manufacturers of the product discussed. For the complete article, please visit the website of Pediatric Anesthesia or Google the title of the article.
a leak pressure of 28 cm H₂O and the patient was intubated with a 4.0 mm ID cuffed T1 using a fiberoptic scope.

Securing the Airway

All patients received 10 mcg/kg IV glycopyrrolate to minimize secretions. The air-Q was deflated and inserted using a rotational technique. The cuff of the air-Q ILA was inflated according to the manufacturer's instructions: Size 1 required <3 ml, size 1.5 required <5 ml, and size 2 required 5-10 ml. The authors' goal was to achieve a minimum leak of 20 cm H₂O while staying within the manufacturer's guidelines for cuff inflation. Leak pressures were obtained by auscultation over the anterior neck while observing the ventilator manometer during a positive pressure breath. Subsequently, mechanical ventilation of about 10 mEq/kg using pressure-limited ventilation was instituted. The airway adapter of the air-Q ILA was removed prior to proceeding with a fiberoptic-assisted intubation. A T1 was loaded on to the fiberoptic scope prior to insertion into the trachea. The patients were ventilated through the T1 still within the air-Q to verify bilateral breath sounds and end-tidal carbon dioxide. The air-Q ILA was easily removed without the aid of a "pusher" or stabilizing rod after intubation. Removal of the air-Q ILA required removal of the T1 adapter, deflation of the air-Q ILA, downward traction on the T1, and distal control of the T1 with the forefinger and thumb, while withdrawing the laryngeal airway. All patients were successfully extubated over an airway exchange catheter.

Summary

Classic LMA has some limitations when it is used as a conduit for intubation. The shaft of the LMA can be as long as the T1, making it difficult to maintain control of the T1 while removing the LMA. Either a long tracheal tube, a double tracheal tube assembly, or a stabilizing rod is required to overcome the length of the LMA. Shortening the shaft of the LMA or leaving the LMA in place for the duration of surgery have also been suggested to minimize these potential risks. The airway connector of the LMA is not wide enough to allow passage of the cuffed T1 pilot balloon. This would result in the pilot balloon "hanging up" within the shaft of the LMA and potentially breaking upon attempted withdrawal of the LMA. When using disposable LMAs, the grill may have to be cut to permit a larger or cuffed T1 when compared with its nondisposable counterpart.

The air-Q ILA has several key structural differences from the classic LMA and thus has the potential to overcome the above limitations. Since the shaft of this airway is much shorter and curved, enough of the proximal T1 is still above it, allowing for removal of the air-Q without the aid of a stabilizing rod. The air-Q ILA can be easily removed with a specially designed removal stylet to prevent dislodging the T1. In the cases outlined above, the patients were intubated on the first attempt with no decrease in oxygen saturation. An AEC was placed through the T1 prior to extubation as a means to re-intubate if needed. The AEC was removed when the patient exhibited adequate respiratory effort, facial grimacing, and hip flexion. There were no postoperative airway complications in any of the patients.

The air-Q ILA is available in sizes 1, 1.5, 2, 2.5, 3.5, and 4.5 for single use and sizes 2.0, 2.5, 3.5, and 4.5 for reusable use. Sizing of the pediatric air-Q ILA, as for the LMA, is weight-based. A size 1 is designed for patients <5 kg, size 1.5 for 5-10 kg, size 2 for 10-20 kg. In the cases presented, various cuffed T1 sizes can be placed through the same size air-Q ILA as seen with patients through, above. The patients demonstrated that a smaller than weight-based size air-Q ILA can be used without compromising ventilation parameters and to allow for tracheal intubation with an appropriately sized cuffed T1. This would not have been possible with an equivalently sized classic LMA. The shaft of the classic LMA does not permit passage of a larger diameter T1 or the pilot balloon of a cuffed T1. While the use of the air-Q may not improve the view when used in conjunction with a flexible fiberoptic scope in the presence of blood and secretions, the alignment with the glottis anatomy may allow for increased success in the use of a "light guarded" or blind technique for intubation. When intubating neonates, intubating either a continuous ventilation technique is employed, a standard bronchoscope adapter will add length to the shaft of the air-Q ILA and the use of the LMA necessitating the use of a stabilizing rod. Once the air-Q ILA airway connector is removed, the bronchoscope adapter will no longer be able to be connected to the shaft.

The authors concluded: "We believe the use of the air-Q ILA may be a well-suited alternative to the classic LMA in children with difficult airways, especially when a cuffed T1 is desired. In these patients with restricted mouth opening, this airway offers many advantages over the traditional LMA-assisted intubation... This device may prove to be a valuable tool in the management of a difficult pediatric airway."

Endnote

In a correspondence in a subsequent issue of the journal in which the aforementioned air-Q study appeared, the respondents wrote: "By way of contribution to this debate, we report the successful use of the ILA in two pediatric patients with a predicted difficult airway and discuss solutions to some practical problems we have encountered in our early experiences with this device." Their first patient was ideally suited for a supraglottic device-assisted technique. The size 2.5 device gave a good airway seal at pressures that allowed easy positive pressure ventilation. A stylet helped to overcome a problem particular to pediatrics, where the ETI can be contained entirely within the shaft of an LMA. The stylet effectively lengthens the ETI to sufficiently allow continuous retention of control of the ETI throughout withdrawal of the ILA over the ETI, which is helpful in reducing the risk of accidental extubation. While the note's authors agreed that the ILA could be withdrawn over the ETI without extending the ETI because of the short, hyper-curved style, they noted that this was awkward. They write that the ETI caused some difficulty. The authors noted that they did not adequately lubricate the lumen of the ILA airway. With better lubrication, they did not have this problem during subsequent intubations through the device. By contrast, in another case,

Continued on page 62...
the authors of the correspondence encountered no difficulty passing the 3.5 cuffed endotracheal tube past the distal aperture of the size 1 ILA. The only problem encountered was an inability to pass the pilot balloon through the ILA lumen. This was handled by cutting off the pilot balloon. Using a 4.0 uncuffed endotracheal tube would have obviated this problem. They noted that the technique of inverting a stylet designed for a larger ETI worked very well but didn’t routinely recommend it because of the theoretical risk of having the end of the stylet advance too far into the endotracheal tube such that it becomes difficult to remove. The correspondents noted: “In summary, we have used a novel supraglottic airway device, the air-Q ILA, as a conduit for fiberoptic intubation in two difficult intubation scenarios.” The correspondents are: Kawshala Peiris, Mike Traynor and Simon Whyte, with BC Children’s Hospital, Vancouver.
**Pediatric Anesthesia**

**ORIGINAL ARTICLE**

**A randomized crossover comparison between the Laryngeal Mask Airway-Unique™ and the air-Q Intubating Laryngeal Airway in children**

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Children's Memorial Hospital, Northwestern University Feinberg School of Medicine, Chicago, IL, USA

**Keywords**

Laryngeal Mask Airway; children; airway devices; equipment air-Q; intubating laryngeal airway

**Correspondence**

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Email: simjag2000@yahoo.com

**Accepted 21 August 2011**


**Introduction**

The laryngeal mask airway LMA-Classic™ and its disposable version, LMA-Unique™ (LMA-U; LMA North America, Inc. San Diego, CA, USA) have a well-established role in pediatric clinical practice with a long history of safety and reliability (1,2). The air-QTM intubating laryngeal airway (ILA, Cookgas LLC, Mercury Medical, Clearwater, FL, USA) is a newer supraglottic airway that can also be used for airway maintenance under general anesthesia (3). The ILA has been shown to be an effective conduit for tracheal intubation with cuffed tracheal tubes in both adults (3) and pediatric patients (4-6), a particular advantage, as

**Summary**

Objectives: The purpose of this randomized crossover study was to evaluate the feasibility of the air-Q intubating laryngeal airway (ILA) in clinical practice when compared with the Laryngeal Mask Airway-Unique™ (LMA-U), the current standard of care for primary airway maintenance.

Aim: We hypothesized that the ILA would have better airway seal pressures and laryngeal alignment than the LMA-U in anesthetized nonparalyzed children.

Background: The ILA is a newer supraglottic airway for children with design features that allow it to be used for primary airway maintenance and as a conduit for tracheal intubations.

Methods: Fifty healthy children, 6-36 months of age, 10-15 kg, who were scheduled for elective surgery in which the use of a size two LMA-U and size 1.5 ILA would be appropriate for airway maintenance were enrolled into this randomized crossover study. Primary outcome measures were airway leak pressures and fiberoptic grades of view. Secondary outcome measures included ease and time for successful insertion, incidence of gastric insufflation, ventilation parameters, and complications.

Results: There were no statistically significant differences in regard to the ease of device insertion, time to ventilation, gastric insufflation, and ventilation parameters between the ILA and the LMA-U. All devices were successfully placed on the first attempt, and there were no instances of failure. There were statistically significant differences in the airway leak pressure between the ILA (19.0 ± 5.4 cmH₂O) and the LMA-U (16.1 ± 4.9 cmH₂O), P = 0.001. There were also statistically significant differences in the fiberoptic grades of view between the ILA and LMA-U, P = 0.004.

Conclusions: The ILA had higher airway leak pressures and superior fiberoptic grades of view when compared with the LMA-U and can be a suitable alternative to the LMA-U in children weighing 10-15 kg.
the LMA-U requires some modifications when used for this purpose. Design features of the ILA, such as a raised mask heel and space above the keyhole-shaped ventilating orifice for the epiglottis to rest, may potentially lead to better airway seal pressures and epiglottic isolation, respectively. Figure 1a highlights the structural features of the mask bowls of the ILA and LMA-U. This prospective randomized crossover study was designed to evaluate the clinical performance of the ILA compared to that of the LMA-U. We hypothesized that the ILA would have better airway seal pressures and laryngeal alignment than the LMA-U. Ease and time for successful insertion, incidence of gastric insufflation, and complications were also evaluated.

Methods

This study was approved by the Children’s Memorial Hospital Research Center’s IRB, and written informed consent was obtained from the parents of all patients. Registration for this study (NCT01314248) can be found at http://clinicaltrials.gov. Fifty children, 6-36 months of age, 10-15 kg, American Society of Anesthesiologists (ASA) physical status I and II, who were scheduled for elective outpatient surgery in the supine position in which the use of a size two LMA-U (10-20 kg) and size 1.5 ILA (7-17 kg) would be appropriate for airway maintenance, were enrolled into this randomized crossover study. Patients were excluded if they had an ASA physical status > II, active respiratory illness (cough, fever, rhinorrhea), risk for aspiration, or a potentially difficult airway.

Both the ILA and LMA-U were inserted in each patient. The order of placement for each case was randomized by a computer-generated list and placed in an opaque envelope by an assistant not involved in the study and only opened by the study investigator just prior to device insertion. General anesthesia was induced with sevoflurane in 70% nitrous oxide and oxygen before intravenous access was obtained. Fentanyl 1 µg·kg⁻¹ was then administered, and the patient was ventilated with 100% oxygen until the heart rate was at least 20% lower than pre-fentanyl value. An endtidal sevoflurane concentration of 3% was main-

Figure 1 (a) The mask bowl of the size 2 laryngeal mask airway-Unique (LMA-U) left and the size 1.5 disposable air-O intubating laryngeal airway (ILA) right. The white arrow on the ILA shows the space above the key-hole-shaped ventilation orifice for the epiglottis to rest. The black arrow highlights the raised mask heel. Both of these structural features may potentially lead to improved epiglottic isolation and airway seal pressures, respectively. Note: the aperture bars present on the LMA-U’s ventilating orifice, which acts to prevent the epiglottis from being drawn into the airway tube. (b) Fiberoptic view through size two LMA-U in an 18-month-old child. Note: the slight inferior displacement of the epiglottis. (c) Fiberoptic view through size 1.5 ILA in same child. Note the isolated epiglottis.
tained prior to and during placement of the two devices. Adequate anesthetic depth was confirmed by the lack of a motor response to jaw thrust (7). A supplementary dose of 1 mg·kg⁻¹ propofol was allowed if the depth of anesthesia was deemed insufficient for device placement as evidenced by a motor response to jaw thrust. The first device was then placed, study parameters measured and recorded (ease and time for successful insertion, airway leak pressure, gastric insufflation, tidal volume with positive pressure ventilation, fiberoptic view), and repeated with the second device after removal of the first device. The second device was left in place for the remainder of the case. Each device was fully deflated and inserted with a standard midline technique according to the manufacturer's recommendations. Bag-mask ventilation was maintained before and between device insertions. Neuromuscular blockade was not utilized in any of the patients.

Two anesthesiologists (NJ and LS) experienced in using both devices (over 300 insertions with both devices) performed all the insertions and were involved in every case. One investigator managed the airway, including insertion of the devices, determining leak pressures, and obtaining fiberoptic views, while the other monitored the intra-cuff pressures and assessed for gastric insufflation. A third study investigator (RM) assisted with the measurement of time, recording photos of the fiberoptic views, and ensured collection of all data.

With the patient's head in neutral position, the time for successful insertion was measured from the moment the facemask was removed until evidence of bilateral chest rise was observed with a positive pressure breath of at least 6 ml·kg⁻¹ tidal volume through the device after cuff inflation. The intra-cuff pressure was then standardized to 60 mmHg (8) using an aneroid cuff pressure gauge (Ambu Inc., Glen Burnie, MD, USA). Intra-operatively, the intra-cuff pressure was monitored and adjusted to not exceed 60 mmHg. Ease of placement was also assessed using a subjective scale of 1-4 (1 = no resistance, 2 = mild resistance, 3 = moderate resistance, 4 = inability to place the device). The insertion would be recorded as a failure if the placement of the device required more than two attempts, lack of a square-wave capnogram tracing, evidence of airway obstruction (oxygen desaturation < 90%, abnormal thoraco-abdominal movements, or obstructive noises), or inadequate ventilation (inability to generate 8-10 ml·kg⁻¹ tidal volumes with positive pressure ventilation). If a second attempt was required, an alternative method of insertion was allowed. The trachea would be intubated if either device could not be placed successfully. To determine the leak pressure, the expiratory valve was closed with a fresh gas flow of 3 l·min⁻¹ until equilibrium was reached (8) (not allowed to exceed 40 cmH₂O) and then released completely. Auscultation with a stethoscope was performed over the epigastrium during leak pressure testing (9) to detect for possible gastric insufflation. Each patient was placed on pressure-controlled ventilation to determine the minimal peak inspiratory pressure required to deliver 8-10 ml·kg⁻¹ tidal volumes while maintaining $\text{ETCO}_2$ 40-45 mmHg. A flexible fiberoptic scope (LF-V 4.1 mm, Olympus America Inc; Melville, NY, USA) was then used to view and record the anatomic alignment of the device to the larynx, just proximal to the airway orifice. Photos were later evaluated and graded using an established scoring system of 1-5 (10) by a blinded independent observer (KL). The images were graded according to: Grade 1, larynx only seen; Grade 2, larynx and epiglottis posterior surface seen; Grade 3, larynx and epiglottis tip of anterior surface seen; < 50% visual obstruction of epiglottis to larynx; Grade 4, epiglottis downfolded and its anterior surface seen; > 50% visual obstruction of epiglottis to larynx; Grade 5, epiglottis downfolded and larynx cannot be seen directly. Grades 1 and 2 were considered optimal, while Grades 3-5 were considered suboptimal for the purpose of fiberoptic-guided tracheal intubations. Positive pressure ventilation was maintained with the second device until recovery of spontaneous respiration, regardless of the fiberoptic grade. Failure of the device during maintenance of anesthesia was defined as inadequate ventilation or airway obstruction (same definition as above for placement failure), with the need for readjustment of the device, or replacement with a tracheal tube. The second device was removed under a deep plane of anesthesia at the conclusion of the procedure. Complications with each device such as airway reflex activation (coughing, laryngospasm, bronchospasm), desaturation (SpO₂ < 90%), gastric insufflation, and blood staining were also noted. All patients were seen in the postanesthesia care unit and also received a follow-up phone call the next day from a registered nurse who was not part of the study to document any postoperative complications such as dysphonia, cough, or stridor as reported by the parents.

Based on the published data from our department, the mean leak pressure with the ILA was 16.6 ± 5.5 cmH₂O (4). Our clinical experience with the ILA and the LMA-U in a small pilot crossover analysis of 20 patients also suggested that the leak pressure was approximately 3.6 cmH₂O greater than that obtained with the LMA-U. In addition, an optimal glottic view was seen in approximately 80% of patients with the ILA and 50% of patients with the
LMA-U. Using these effect sizes, an alpha of 0.05 and a desired power of 0.8, we estimated that 37 patients would be required to demonstrate a statistically significant difference in the leak pressure and 45 patients would be required to demonstrate a statistically significant difference in obtaining an optimal fiberoptic grade of view between these two devices. The study was designed to enroll 50 patients allowing for possible exclusions.

Data were recorded intra-operatively using a standardized data collection sheet and analyzed using Microsoft Excel Spreadsheet and the statistical software PASW Statistics 18 (SPSS Inc., Chicago, IL, USA). Statistical comparisons between devices were performed using paired Student's t-tests and Student's t-tests for continuous data, chi-square tests for categorical data, Mann-Whitney U and Wilcoxon signed rank tests for ordinal data. Unless otherwise stated, data are presented as mean (±sd). A P-value < 0.05 was considered statistically significant.

Results

Sixty-eight patients were screened for enrollment in this study. After the study was explained and the consent was read, 18 parents declined to participate. Fifty patients undergoing a variety of outpatient procedures with a mean age of 19.6 ± 6.5 months and a mean weight of 11.5 ± 1.3 kg were then subsequently enrolled. None of the patients were excluded because of a violation in study protocol or refusal to participate after the consent was signed. Prior to statistical analysis, data were analyzed separately to rule out a carryover effect. The analysis did not indicate a significant influence of the first device on the results of the second device. Patient demographics are presented in Table 1 and comparative data in Table 2.

There were no statistically significant differences in regard to the ease of device insertions, times to effective

<table>
<thead>
<tr>
<th>Parameters tested</th>
<th>LMA-U (n = 50)</th>
<th>ILA (n = 50)</th>
<th>P-value</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ease of device placement* (1/2/3/4)</td>
<td>43/6/1/0</td>
<td>37/12/1/0</td>
<td>0.166</td>
<td>Wilcoxon signed ranks test</td>
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<tr>
<td>Time to successful ventilation (s)</td>
<td>10.6 ± 2.4</td>
<td>11.1 ± 2.5</td>
<td>0.148</td>
<td>t-test</td>
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<tr>
<td>Airway leak pressure (cmH₂O)</td>
<td>16.1 ± 4.9</td>
<td>19.0 ± 5.4</td>
<td>&lt;0.001</td>
<td>t-test</td>
</tr>
<tr>
<td>Gastric insufflation, n (%)</td>
<td>7 (14%)</td>
<td>5 (10%)</td>
<td>0.538</td>
<td>Chi-square</td>
</tr>
<tr>
<td>Positive pressure ventilation parameters</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Peak pressure (cmH₂O)</td>
<td>13.2 ± 2.0</td>
<td>13.1 ± 2.0</td>
<td>0.841</td>
<td>t-test</td>
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<tr>
<td>Tidal volume (ml)</td>
<td>115.3 ± 27.8</td>
<td>120.3 ± 24.3</td>
<td>0.075</td>
<td>t-test</td>
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<td>Fiberoptic examination</td>
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<tr>
<td>Grade of view* (1/2/3/4/5)</td>
<td>8/14/15/10/3</td>
<td>20/14/7/6/3</td>
<td>0.004</td>
<td>Wilcoxon signed ranks test</td>
</tr>
<tr>
<td>Optimal/Suboptimal (% optimal)</td>
<td>22/28 (44%)</td>
<td>34/16 (68%)</td>
<td></td>
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<tr>
<td>Complications</td>
<td></td>
<td></td>
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<tr>
<td>Reflex activation of airway</td>
<td>0/1</td>
<td>0</td>
<td>Frequencies too small to be calculated by chi-square analysis</td>
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<td>(bronchospasm/laryngospasm)</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Blood staining</td>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postoperative cough/Dysphonia</td>
<td>1/1</td>
<td>2/0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Results are reported as mean ± sd. P < 0.05 designates a statistically significant difference between cohorts.

*Ease of insertion grading was based on a subjective scale of 1-4: 1 = no resistance, 2 = mild resistance, 3 = moderate resistance, 4 = inability to place the device.

**Fiberoptic grade of view was assessed using the following scoring system: Grade 1, larynx only seen; Grade 2, larynx and epiglottis posterior surface seen; Grade 3, larynx and epiglottis tip of anterior surface seen, <50% visual obstruction of epiglottis to larynx; Grade 4, epiglottis downfolded and its anterior surface seen, >50% visual obstruction of epiglottis to larynx; Grade 5, epiglottis downfolded and larynx cannot be seen directly. Grades 1 and 2 were considered optimal, while Grades 3-5 were considered suboptimal for the purpose of fiberoptic-guided tracheal intubations.
tive ventilation, gastric insufflation rates, and positive pressure ventilation parameters between the ILA and the LMA-U. Propofol was administered for inadequate anesthetic depth in two patients, one from each group, and prior to the insertion of the first device only. All devices were successfully placed on the first attempt, and there were no instances of device failure during maintenance of anesthesia or need for conversion to a tracheal tube.

There were statistically significant differences in the airway leak pressures between the ILA (19.0 ± 5.4 cmH₂O) and the LMA-U (16.6 ± 4.9 cmH₂O), \( P = 0.001 \). There were also statistically significant differences in the fiberoptic grades of view between the ILA and the LMA-U, \( P = 0.004 \) (Figure 2). Optimal (Grade I and 2) fiberoptic views were seen in 34/50 patients with the ILA and 22/50 patients with the LMA-U. Figure 1b,c show examples of fiberoptic views through these devices.

There were 12 cases of gastric insufflation during leak pressure testing: five of these occurred with the ILA, seven with the LMA-U; none resulting in oxygen desaturation. Blood staining was only seen with one patient after the insertion of an LMA-U, which was the first device, and not associated with any difficulty on placement. Laryngospasm occurred in one patient and was related to the placement of an oral airway on emergence of anesthesia after removal of the second device and was promptly resolved with positive pressure via bag-mask ventilation. Follow-up phone calls revealed postoperative complications as reported by the parents in two cases in which an LMA-U was the second device: dysphonia (\( n = 1 \)) and coughing (\( n = 1 \)). In the cases with an ILA as the second device, there were also two postoperative complications: coughing (\( n = 2 \)). There were no episodes of gastric regurgitation, aspiration, bronchospasm, or stridor in any of the patients.

**Discussion**

The main findings in this study are that in anesthetized, nonparalyzed children, the ILA is associated with higher airway leak pressures and superior fiberoptic grades of view when compared with the LMA-U.

The time taken to establish an effective airway, first attempt success rates, and the ease of insertion were similar for both devices. The insertion success rates in this study are comparable to other studies on the LMA-U (11-13) and ILA (4) with experienced users. These similarities imply that the experience of the clinician may be a factor influencing these parameters.

The airway leak pressures of the ILA were found to be higher than those of the LMA-U in this study. However, these values are within the range of airway leak pressures reported for the LMA-Classic (12,14,15), and further studies are required to define any clinical relevance. Leak pressure differences may not have a clinical significance during spontaneous ventilation, but may be a consideration if positive pressure ventilation were needed. A possible explanation for the improved airway seal may be because of the ILA’s design for isolating the epiglottis above the ventilating orifice and its raised mask heel. The incidence of gastric insufflation for both devices was low and may indicate that the two devices have similar hypopharyngeal seal characteristics.

The LMA-U has been shown to be a safe alternative for positive pressure ventilation when used with appropriate precautions (16, 17). The results of this study support this finding for the LMA, but definitive conclusions cannot be made regarding the ILA. Although all patients in this study underwent adequate controlled ventilation with both devices, parameters to fully assess the ILA’s performance for airway maintenance with positive pressure ventilation were not tested. Effective ventilation was provided in all cases despite the lack of neuromuscular blockade, regardless of the airway leak pressure, and likely due to the selection of healthy patients with good lung compliance. Further studies are needed to evaluate the utility of the ILA for airway maintenance with controlled ventilation.

In this study, overall fiberoptic grades of view were more favorable through the ILA when compared with...
the LMA. Additionally, there were more Grade I views with the ILA. The design of the ILA, with an area above the ventilating orifice for the epiglottis to rest on when properly positioned, may have contributed to this finding. Of note, this structural feature has recently been modified in the smaller ILA sizes (1 and 1.5) and may have improved the fiberoptic views when compared with the original reports on their use in children (4, 5). Fiberoptic views with the LMA-U in this study are consistent with other studies using the size two LMA (14, 15). Even with complete epiglottic downfolding, both devices provided adequate ventilation parameters without evidence of airway obstruction, which is consistent with previous literature (4, 18-22). The lower rates of epiglottic downfolding seen with the ILA in this study may highlight a potential advantage when considering fiberoptic-guided tracheal intubations, especially when cuffed tracheal tubes are desired (4).

There were very few complications with the use of both devices in this study and did not appear to be related to difficulty on placement or length of the procedure. The rate of blood staining noted in this study is consistent with prior studies for the ILA but lower than previous reports for the LMA (14, 23). A possible reason for this finding is that each device was successfully placed on the first attempt without difficulty, reducing the probability of mucosal trauma. The use of neuromuscular blockade may afford some degree of safety by reducing potential problems such as reflex activation of the airway associated with device placement. The low complication rate in this study is particularly reassuring given that neuromuscular blockade was not utilized.

Several limitations exist in this study. First, only healthy patients weighing 10-15 kg with normal airways were enrolled. Second, all devices were inserted by two experienced anesthesiologists, and the resulting data may not be applicable to less-experienced clinicians. Third, the leak pressure data were collected by an unblinded observer and may be a possible source of bias. Fourth, our data may not apply to children who receive neuromuscular blockade for positive pressure ventilation. Fifth, although variability in anesthetic depth can be a confounding factor, a significant carry-over effect was not seen in the results.

In conclusion, the ease of insertion, time to successful ventilation, complications, and overall clinical performance were similar for both devices, suggesting the use of the ILA as a suitable alternative to the LMA-U in children. However, the superior epiglottic islation of the ILA may have increased utility for fiberoptic-guided tracheal intubation when compared with the LMA-U. Further studies are required to judge the overall safety of this device and the role for positive pressure ventilation in children.

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The equipment used in this study was provided by generous product support by the manufacturers.

Conflicts of interest

No conflicts of interest declared.

References

Crossover comparison between the air-Q ILA and LMA-U in children


Retrospective audit of the air-Q intubating laryngeal airway as a conduit for tracheal intubation in pediatric patients with a difficult airway

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Keywords
pediatric difficult airway; intubating laryngeal airway; air-Q; intubating LMA; LMA

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Summary

Objectives: To assess the efficacy of the ILA as a conduit for tracheal intubation in pediatric patients with a difficult airway.

Aim: The primary goals of this retrospective audit were to assess the clinical performance of the ILA in pediatric patients with a difficult airway, expand on our initial favorable experience with this device, and collect pilot data for future prospective and comparison studies.

Methods: The charts of patients with a difficult airway in whom the ILA was used during a period of 1 year in a freestanding pediatric institution were reviewed following a practice change in the authors’ institution favoring the ILA over the laryngeal mask airway as a conduit for tracheal intubation.

Results: Thirty-four pediatric patients had an ILA placed during the course of their airway management. Eight of the 34 patients in this cohort required emergent airway management. The median age was 47.1 (0.3–202.2) months and the median weight was 16.3 (3.9–86.0) kilograms. Three of the cases were unanticipated difficult airways and the remaining were anticipated difficult airways as a result of craniofacial syndromes (n = 21), cervical spine instability or immobility (n = 7), or airway hemorrhage (n = 3). Thirty-three of the 34 patients (97%) were intubated on the first attempt through the ILA, with the aid of a fiberoptic bronchoscope (n = 25), a Shikani Optical Stylet (n = 7), or blindly (n = 2). In one patient, blind tracheal intubation required a second attempt for successful intubation, making the overall success rate 100%. Oxygen desaturation was noted in 6 of the 34 cases.

Conclusions: Visualization techniques may offer a greater degree of success in intubations through the ILA due to the potential for epiglottic down-folding in children.
Introduction

Supraglottic airway devices are an integral part of airway management in infants and children. Since its introduction, the laryngeal mask airway (LMA®; LMA North America; San Diego, CA, USA) has been modified to suit various applications, most notably for tracheal intubations. In addition to the LMA, the adult intubating LMA has a well-defined role in clinical practice for the management of difficult airways (1–3). Since a pediatric intubating LMA is not yet available, the LMA is commonly used to assist tracheal intubation in pediatric patients (4–7). However, there are well-known limitations to the use of the LMA for this purpose. First, the airway tube of the LMA can be as long as the tracheal tube making it difficult to maintain control during removal of the LMA. Second, the insufficient width of the LMA airway tube may result in entrapment and potential breakage of the cuffed tracheal tube pilot balloon. Third, a stabilizing rod is not available for the classic LMA and modifications of the tracheal tube or LMA are often required to allow for successful tracheal intubation and subsequent removal of the LMA (8–11).

The air-Q® intubating laryngeal airway (ILA®; Cookgas LLC, Mercury Medical, Clearwater, FL, USA) is a supraglottic airway device designed to allow for tracheal intubation with a cuffed tracheal tube and to facilitate easy removal with a custom removal stylet1 following tracheal intubation. The ILA shares similar design features with the adult intubating LMA (Figure 1), while having smaller sizes available for patients under 30 kg2, making it useful for tracheal intubation in pediatric patients. The purpose of this retrospective audit was to evaluate the utility of this device as a conduit for tracheal intubation on pediatric patients with a difficult airway, after a change in practice at the authors’ institution where use of the ILA became the primary approach over the LMA for tracheal intubation in pediatric patients with a difficult airway. The key words used to determine the cases to be included were: anticipated or unanticipated difficult airway, difficult mask ventilation, cervical spine instability or immobility, various craniofacial syndromes associated with a difficult airway, and acute respiratory distress. A manual chart review of these results was conducted to identify those patients in whom the ILA was used as a conduit for tracheal intubation. Patients that were 16 years of age and under were included in the final analysis.

Demographic data were collected, including age, gender, American Society of Anesthesiologists (ASA) status, reason for difficult airway, and Cormack and Lehane grade upon direct laryngoscopy if attempted prior to placement of the ILA (12). Charts were also reviewed for the ILA size used, size and type of tracheal tube placed, any airway manipulations performed (jaw thrust and/or application of anterior laryngeal pressure), and the recorded grade of the endoscopic glottic view through the Shikani Optical Stylet (LLC; Clarus Medical, Minneapolis, MN, USA) or the fiberoptic bronchoscope. Endoscopic grade was defined as Grade 1, larynx only seen; Grade 2, larynx and epiglottis posterior surface seen; Grade 3, larynx and epiglottis tip of anterior surface seen, <50% visual obstruction of epiglottis to larynx; Grade 4, epiglottis down-folded and its anterior surface seen, >50% visual obstruction of epiglottis to larynx; Grade 5, epiglottis down-folded and larynx cannot be seen directly (13). The total number of failed attempts for tracheal intubation employing alternative methods, number of attempts needed when the ILA was used as a conduit for intubation, success rate and method of removal of the ILA, location where airway management took place, indications for emergent airway management, and complications (i.e., laryngospasm, bronchospasm, aspiration, SpO2 < 85%) were also recorded. No previously reported patients (14) were included in this study. All data were entered in an Excel database and analysis was performed using Microsoft Excel 2007 (Microsoft Corporation, Redmond, WA, USA).

Methods

After receiving approval from the Institutional Review Board, a search was conducted on our institution’s electronic medical record database to identify patients who received general anesthesia and were noted to have a difficult airway from January 2009 to January 2010. This 12-month period followed a practice change at the authors’ institution where use of the ILA became the primary approach over the LMA for tracheal intubation in pediatric patients with a difficult airway. The air-Q® Intubating Laryngeal Mask package insert at: http://cookgas.com/assets/Documents/EnglishInsert.pdf Accessed 5 August, 2010. edition 4.2 Air-Q Intubating Laryngeal Mask package insert at: http://cookgas.com/assets/Documents/EnglishInsert.pdf Accessed 5 August, 2010.

Results

Of 16,685 patients receiving general anesthesia during a period of 1 year in a freestanding pediatric institution, 54 patients had a difficult airway. Thirty-five of these patients had an ILA placed for tracheal intubation; however, one patient was excluded from the final analysis as he was above the age of sixteen. Of the nineteen patients who had a difficult airway but did not have an ILA placed; six underwent successful fiberoptic oral or nasal intubation, 10 had a supraglottic airway device placed but were not intubated, and three were intubated with a Shikani Optical Stylet, either due to anesthesiologist preference or narrow mouth opening precluding insertion of the ILA.

In the 34 eligible patients who had an ILA placed, most of the airway interventions were performed in the operating room (n = 28). Additionally, two cases took place in off-site locations (magnetic resonance imaging and interventional radiology), two in the intensive care unit, and two in the emergency department. Eight of the 34 patients required emergent airway management. Indications for emergent intubation included acute respiratory distress (n = 4), airway hemorrhage (n = 3), and acute pulmonary edema (n = 1).

The median age was 47.1 (0.3–202.2) months and the median weight was 16.3 (3.9–86.0) kilograms. Five patients were ASA physical status of I (two I–E), 12 ASA II, 15 ASA III (three III–E), and two ASA IV–E. In three of the cases, direct laryngoscopy was unexpectedly difficult due to lingual tonsillar hyperplasia in one patient, and an extreme anterior view in the other two. The remaining cases were all anticipated to be difficult laryngoscopies as a result of craniofacial syndromes (n = 21), cervical spine instability or immobility (n = 7), or airway hemorrhage (n = 3) (Table 1). Two of the patients with craniofacial syndromes also had a diagnosis of mucopolysaccharidosis and were difficult to mask ventilate.

Selection of the ILA size was based on the manufacturer’s recommendation and the attending anesthesiologist’s clinical judgment. Five size 1.0, 11 size 1.5, 10 size 2.0, 6 size 2.5, and 2 size 3.5 ILAs were used. In all patients, the ILA was placed successfully on the first attempt with adequate lung ventilation and capnography waveform. Twenty five patients were intubated using a fiberoptic bronchoscope through the ILA (LF-P outer diameter 2.1 mm, LF-V outer diameter 4.1 mm, LF-TP outer diameter 5.2 mm; Olympus America Inc., Melville, NY, USA). Grades for the fiberoptic views were documented on all of these patients. Sixteen patients had a Grade 1 view, five had a Grade 2 view, three had a Grade 3 view, and one patient had a Grade 5 view with complete epiglottic down-folding which was easily bypassed with the fiberoptic bronchoscope. In seven patients, the Shikani Optical Stylet was used to aid intubation. Of the views obtained, one was Grade 2, three were Grade 3, and three were Grade 4. All these patients required jaw thrust and anterior laryngeal pressure to facilitate intubation using the Shikani Optical Stylet. Two patients underwent blind intubation through the ILA. Cuffed tracheal tubes were used in 33 of the 34 cases. Thirty-three of the 34 patients (97%) were intubated on the first attempt through the ILA. One patient undergoing blind tracheal intubation required a second attempt for successful intubation. There was an overall success rate of 100% for ILA guided tracheal intubation in all patients (n = 34).
Table 1 Demographics and difficult airway management data for patients who were intubated through the air-Q intubating laryngeal airway

<table>
<thead>
<tr>
<th>No.</th>
<th>Age (months)</th>
<th>Cause of difficult airway</th>
<th>ILA size</th>
<th>Device used for intubation</th>
<th>Endoscopic grade of view</th>
<th>Comments</th>
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<td>FO</td>
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<td>FO</td>
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<td>FO</td>
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<td>FO</td>
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<td>FO</td>
<td>I</td>
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<td>V</td>
<td>Difficult mask and ILA ventilation</td>
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<td>Shikani</td>
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<td>FO</td>
<td>I</td>
<td>LMA placed and intubation successful, pilot balloon rupture upon LMA removal prior to ILA insertion</td>
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<td>29</td>
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<td>Airway Hemorrhage</td>
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<td>FO</td>
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<td>Shikani</td>
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Intubating Laryngeal Airway (ILA), Laryngeal Mask Airway (LMA), Direct laryngoscopy (DL), Fiberoptic bronchoscopy (FO), Shikani optical stylet (Shikani), Cormack and Lehane (C & L) grades of view: Grade I, most of glottis is seen; Grade II, only posterior portion of glottis is seen; Grade III, only epiglottis is seen; Grade IV, neither epiglottis nor glottis is seen. Endoscopic grades of view: Grade 1, larynx only seen; Grade 2, larynx and epiglottis posterior surface seen; Grade 3, larynx and epiglottis tip of anterior surface seen, less than 50% visual obstruction of epiglottis to larynx; Grade 4, epiglottis down-folded and its anterior surface seen, greater than 50% visual obstruction of epiglottis to larynx; Grade 5, epiglottis down-folded and larynx cannot be seen directly.
In 10 of the cases, failed attempts to intubate by direct laryngoscopy and/or AIRTRAQ® optical laryngoscope (King Systems, Noblesville, IN, USA) preceded the use of the ILA. The Cormack and Lehane grades of the glottic views by direct laryngoscopy, and fiberoptic bronchoscopy through the ILA are shown in Table 1.

Three patients were initially managed with an LMA prior to the placement of the ILA. Two of these patients had a Grade 3 view through the LMA with the fiberoptic bronchoscope and tracheal intubation was successful through the LMA. However, the tracheal tube became dislodged with rupturing of the cuff line on removal of the LMA. This prompted a conversion to the ILA for securing a cuffed tracheal tube with improvement to a Grade 1 view in both patients.

In the third patient, the airway was rescued with the LMA in the face of airway hemorrhage. Blind intubation was attempted twice without success, leading to placement of the ILA and successful blind tracheal intubation on the first attempt.

In all cases, the ILA was removed after tracheal intubation using either a custom stylet or a second tracheal tube as a stabilizing rod without dislodgement of the tracheal tube. Oxygen desaturation (SpO2 < 85%) was noted in six cases. There was one death documented in a critically ill child in the intensive care unit, despite successful tracheal intubation with the ILA. There were no reports of laryngospasm or bronchospasm in any of the cases.

Discussion
The occurrence of difficult airways in children is rare, usually anticipated, and commonly secondary to a craniofacial syndrome (15,16). As defined in the ASA difficult airway guidelines (1), a difficult airway is the inability to provide face mask ventilation and/or difficult direct laryngoscopy. The incidence of difficult intubation (54 of 16 685; 0.32%) and difficult mask ventilation (3 of 16 685; 0.018%) in the authors’ institution is similar to what has been reported by the Children’s Hospital of Philadelphia of 0.25% and 0.02% respectively (17). In comparison, the incidence of difficult intubation at adult institutions occurs in 1.5-8.5% (18).

Of the 53 eligible patients found to be difficult to intubate, the ILA was successfully used in 34 patients. Awake tracheal intubations are not usually performed in children because of their inability to cooperate and their propensity toward hypoxemia with the use of heavy sedation. The use of a supraglottic airway device may be ideal in a child with a difficult airway because it provides a conduit for tracheal intubation and permits oxygenation and ventilation prior to and during intubation attempts (19). This is very critical in the neonatal and infant populations where oxygen desaturations can be more pronounced.

Design features which attempt to isolate the epiglottis, seen in both the ILA and intubating LMA (Figure 1b), may facilitate blind intubations through the ILA. However, in this study, there were several instances of epiglottic down-folding when using the fiberoptic bronchoscope or Shikani Optical Stylet through the ILA. Although blind intubation was successful in two patients, the incidence of epiglottic obstruction in several patients in this population does not validate the use of routine blind intubations through the ILA in children with difficult airways. This is especially significant when experience with tracheal intubation via the ILA is being gained. Blind intubation has similarly been cautioned against when using the LMA as a conduit for tracheal intubation because of the higher probability of epiglottic obstruction and the potential for esophageal intubation (20,21).

An improvement of the glottic view was seen with a fiberoptic bronchoscope through the ILA in patients who had first been managed with direct laryngoscopy, AIRTRAQ, or LMA guided tracheal intubation. The superior view was likely secondary to the ability of the ILA to isolate the epiglottis, but even when a down-folded epiglottis was encountered, the clinician was able to maneuver past the glottic obstruction with a fiberoptic bronchoscope. Visualization of the relational anatomy through the ILA with either the fiberoptic bronchoscope or the Shikani Optical Stylet can be useful in assisting with tracheal intubations. The Shikani Optical Stylet can also be helpful as a confirmatory aid in trans-illuminating the anterior neck via the ILA. Furthermore, the greater amount of mouth opening required to perform laryngoscopy with the AIRTRAQ and a cephalad larynx may be a possible reason for these patients’ inferior Cormack and Lehane grades.

Like many pediatric practices, our institution has used the LMA with success for many years as a conduit for tracheal intubation in children with a difficult airway (6,7). However, due to its limitations, modifications of the tracheal tube or the LMA itself (8–11,22,23) are necessary, particularly when intubation with cuffed tracheal tubes are needed (9,14). For these reasons, and the increased use of cuffed tracheal tubes in pediatric practice, the current primary approach for managing difficult airways in the author’s institution is to use the ILA.
There are several limitations to the use of the ILA. Although the ILA was found to be easy to place even in patients with difficult airways, a certain degree of mouth opening is still required for insertion of this device. Therefore patients with severe restrictions in mouth opening were not included in this study and exclusion of these patients may overestimate the efficacy of this device in children with difficult airways. Another disadvantage of the ILA is the lack of a gastric drain tube access, which may be desirable in the patient with a full stomach.

Limitations to this study include its (i) retrospective nature, (ii) lack of a control device, and (iii) inability to standardize patients, anesthetics, and data documented. Furthermore, some patients with difficult airways managed with the ILA may have been missed due to potential inconsistent documentation of anesthetic records. This retrospective assessment of the clinical performance of the ILA in pediatric patients with a difficult airway has expanded on our initial favorable experience with this device, and offers initial pilot data for future prospective and comparison studies.

In summary, tracheal intubation via the ILA was successful in all patients with difficult airways. The ILA was also easy to remove after tracheal intubation without dislodgement of the tracheal tube. Fiberoptic bronscopes and optical stylets may offer a greater degree of success in intubations through the ILA in patients with difficult airways due to the potential for epiglottic down-folding in children.

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None.

References
Supraglottic Airways
As Bridges to Safe Extubation
Of the Difficult Airway

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Difficult airway management (DAM) does not end with successful tracheal intubation (TI). In fact, the adoption of established DAM guidelines and the availability of numerous advanced airway management devices have significantly reduced the incidence of patient injury occurring during TI.

According to analyses of the American Society of Anesthesiologists' (ASA) Closed Claims database, although airway-related patient injury including brain death and mortality occurring during TI has decreased substantially, it remains unchanged for all other phases of anesthesia management, including the immediate period after extubation. Data from the United Kingdom show similar trends. The fourth National Audit Project (NAP4) of the Royal College of Anaesthetists and the Difficult Airway Society (DAS) in the United Kingdom reported that major airway complications occur during emergence and recovery from anesthesia in approximately one-third of all adverse events related to anesthesia.

These data highlight the fact that tracheal extubation (TE) and the immediate postextubation period are among the most challenging phases of anesthesia management. Clinicians should plan carefully for these phases, particularly in patients with difficult airways or with limited airway access.

To address this issue, the ASA Task Force on Management of the Difficult Airway has recently recommended a staged extubation strategy when uncertainty exists regarding the ability of the patient to maintain adequate ventilation after TE. The short-term use of an airway device that can serve as a guide for expedited reintubation, if needed, should be considered in patients at risk for failed extubation. The use of such a "bridging" device can confer reversibility to the extubation process and allow tracheal reintubation in a timely manner. Ideally, the device should be placed before TE. The endotracheal tube (ETT) is then removed and the device remains in place until it can be withdrawn safely. The guidelines recommend the use of either an airway stylet/catheter or a supraglottic conduit for bridging. The DAS also has published its recommendations and guidelines for the management of TE with descriptions of the use of some of these bridging devices.

Extubation Failure
Extubation failure has been defined as the inability to maintain adequate ventilation after removal of the ETT. The underlying mechanisms are airway obstruction, hypoventilation, inability to clear secretions or protect the airway, or airway trauma during TI or surgery. The
management of extubation failure is reintubation. Table 1 summarizes some of the causes of extubation failure. It should not be confused with "weaning failure," which is a totally different clinical entity that entails failure to maintain adequate spontaneous ventilation without mechanical ventilatory assistance and can be managed either by invasive or noninvasive ventilatory support.6 Although the focus of extubation failure should be on the ETT as the therapeutic measure, in weaning failure the focus should be on the ventilator.

AIRWAY RISK FACTORS AND STRATIFICATION OF EXTUBATION RISK

The ability to recognize situations of high-risk extubation is probably the most crucial step in preventing mishaps related to TE. Although no study has investigated extubation risk factors or the correlation between each factor and the incidence of reintubation, anecdotal data and case reports provide helpful tools to the practitioner to identify and stratify patients into 3 broad groups.7

The low-risk extubation group consists of nonobese patients with negative history of difficult intubation or sleep apnea, whose airway exam is normal, and who are scheduled for a non-airway, head, or neck surgery. Routine TE can be performed safely in these patients.

The intermediate-risk group includes patients in whom there is uncertainty regarding the ability to tolerate extubation, but in whom reintubation is not expected to be problematic and can be easily performed when needed. Examples are patients with vocal cord dysfunction, such as paradoxical vocal cord motion, mild degrees of tracheomalacia, airway granulomas and sarcoid masses, and pharyngeal muscle dysfunction, such as parkinsonism with normal upper airway exam. Although airway obstruction can occur in those patients after TE, mask ventilation and/or reintubation are expected to proceed uneventfully.

The high-risk extubation group comprises patients in whom there is uncertainty regarding the ability to tolerate extubation and it is almost certain that mask ventilation and/or reintubation can be difficult if needed (Table 2).3

In each of these groups, the assumption is that the decision has been made that TE can be performed safely or is desirable. Because TE is an elective procedure, a decision must be made in each individual case whether it is safe to remove the ETT or to keep the trachea intubated for a certain period of time postoperatively until extubation conditions are more favorable. We would like to add a fourth group to these classifications. It includes patients who most likely will fail extubation, those for whom reintubation can be extremely difficult or impossible, those who cannot tolerate even brief periods of hypoventilation, those for whom extubation conditions are expected eventually to improve, and patients with no clear indication for immediate extubation. The approach for patients in this group should be to postpone TE until the conditions improve and it can be performed safely. Evidently, the most challenging patients are those in

<table>
<thead>
<tr>
<th>Table 1. Causes of Extubation Failure8</th>
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<tbody>
<tr>
<td><strong>Airway Obstruction</strong></td>
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<tr>
<td>Anterior cervical decompression</td>
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<tr>
<td>Maxillofacial trauma</td>
</tr>
<tr>
<td>Neck hematoma</td>
</tr>
<tr>
<td>No cuff leak</td>
</tr>
<tr>
<td>Obstructive sleep apnea</td>
</tr>
<tr>
<td>Paradoxical vocal cord motion</td>
</tr>
<tr>
<td>Post-thyroidectomy</td>
</tr>
<tr>
<td>Post-carotid endarterectomy</td>
</tr>
<tr>
<td>Post-panendoscopy</td>
</tr>
<tr>
<td>Post-uvulopalatopharyngoplasty</td>
</tr>
<tr>
<td>Recurrent laryngeal nerve palsy</td>
</tr>
<tr>
<td>Tracheomalacia</td>
</tr>
<tr>
<td><strong>Hypoventilation syndromes</strong></td>
</tr>
<tr>
<td>Central sleep apnea</td>
</tr>
<tr>
<td>Diaphragmatic splinting</td>
</tr>
<tr>
<td>Excess carbon dioxide production</td>
</tr>
<tr>
<td>Preexisting neuromuscular disorder</td>
</tr>
<tr>
<td>Residual anesthetic or muscle relaxant effects</td>
</tr>
<tr>
<td>Severe chronic obstructive pulmonary disease</td>
</tr>
<tr>
<td><strong>Hypoxemic respiratory failure</strong></td>
</tr>
<tr>
<td>Decreased oxygen delivery</td>
</tr>
<tr>
<td>Impaired pulmonary diffusion</td>
</tr>
<tr>
<td>Inadequate inspired oxygen concentration</td>
</tr>
<tr>
<td>Increased oxygen consumption</td>
</tr>
<tr>
<td>Right-to-left shunt</td>
</tr>
<tr>
<td>Ventilation/perfusion mismatch</td>
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<tr>
<td><strong>Pulmonary toilet</strong></td>
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<tr>
<td>Neuromuscular impairment</td>
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<tr>
<td>Obtundation</td>
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<tr>
<td>Pulmonary secretions</td>
</tr>
<tr>
<td><strong>Inability to protect airway</strong></td>
</tr>
<tr>
<td>Decreased level of consciousness</td>
</tr>
<tr>
<td>Neuromuscular weakness</td>
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Table 2. Examples of High-Risk Extubation

<table>
<thead>
<tr>
<th>Condition</th>
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<tr>
<td>Airway burns, neck flexion deformity or scar, irradiation</td>
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<tr>
<td>Anterior and posterior cervical spine surgery</td>
</tr>
<tr>
<td>Burn patients with smoke inhalation injury</td>
</tr>
<tr>
<td>Carotid endarterectomy</td>
</tr>
<tr>
<td>Certain surgical procedures</td>
</tr>
<tr>
<td>Cervical spine immobilization (halo vest)</td>
</tr>
<tr>
<td>Diaphragmatic splinting</td>
</tr>
<tr>
<td>Documented previous difficulty with mask ventilation and/or tracheal intubation</td>
</tr>
<tr>
<td>Extensive neck dissection</td>
</tr>
<tr>
<td>General medical conditions</td>
</tr>
<tr>
<td>Guardian suture fixing chin to chest after tracheal resection</td>
</tr>
<tr>
<td>Intermaxillary fixation and wiring</td>
</tr>
<tr>
<td>Limited airway access</td>
</tr>
<tr>
<td>Maxillofacial surgery</td>
</tr>
<tr>
<td>Multiple attempts at tracheal intubation and/or use of alternative airway devices and techniques for intubation at start of surgery</td>
</tr>
<tr>
<td>Obstructive sleep apnea</td>
</tr>
<tr>
<td>Parkinsonism</td>
</tr>
<tr>
<td>Pharyngeal, laryngeal, or tracheal trauma during intubation (eg, arytenoid dislocation, vocal cord avulsion, laryngeal edema)</td>
</tr>
<tr>
<td>Posterior fossa surgery</td>
</tr>
<tr>
<td>Previous or current airway difficulty</td>
</tr>
<tr>
<td>Rheumatoid arthritis</td>
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<tr>
<td>Submandibular, submental, retro- and parapharyngeal infections</td>
</tr>
<tr>
<td>Thyroid surgery</td>
</tr>
<tr>
<td>Tracheal resection</td>
</tr>
<tr>
<td>Tracheomalacia</td>
</tr>
<tr>
<td>Vocal cord and laryngoscopic surgery</td>
</tr>
<tr>
<td>Vocal cord dysfunction (paradoxical vocal cord motion)</td>
</tr>
<tr>
<td>Uvulopalatopharyngoplasty</td>
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</table>

group 3, as they are most likely to experience rapid deterioration after extubation—and poor planning and preparation may lead to a high rate of morbidity and mortality. It is also the group for whom the revised ASA guidelines recommend the use of a well-planned extubation strategy with the aid of some airway devices as discussed here.

Extubation Strategies and Devices For Bridging

No single device or technique works in every situation. The decision to use a specific device should be based on the specific case scenario and the familiarity and expertise of the managing anesthesiologist. With this in mind, the device that should be considered as a bridge to safe extubation of the difficult airway should accomplish the following:

- Allow patient oxygenation and ventilation until the airway is no longer at risk
- Assist in accomplishing expedited reintubation, if required, after TE
- Allow uninterrupted airway access
- Not interfere with patient comfort or cause further complications

The ASA task force has recommended the consideration of either an ETT exchanger or stylet and/or a supraglottic airway (SGA) as bridges for safe extubation of the high-risk airway.4

**ETT EXCHANGER OR STYLET**

A wide variety of airway exchange catheters and tracheal tube introducers are commercially available and can be used for this purpose. Examples include Eschmann introducers (SunMed), Frova intubating introducers (Cook Medical Inc.), Cook airway exchange catheters (AECs), Arndt AECs (Cook Medical Inc.), endotracheal ventilation catheters (CardioMed), and Aintree catheters (Cook Medical Inc.). Each of these devices has external depth markings and can be passed through the existing ETT to a predetermined depth. The ETT is then removed and the catheter or stylet is fixed and left in place until it can be removed safely.

Hollow catheters are preferable to solid ones, as they permit oxygen insufflation or ventilation. Their use for insufflation or ventilation, however, may result in fatal complications and therefore recently has been discouraged except as a last resort.9 If reintubation is deemed necessary, the new ETT can be railroaded over the catheter. The reported success of reintubation with the use of these catheters in failed extubation situations in a difficult airway, or in an airway with limited access, had made their use popular.10 However, complications may limit their use in favor of other devices that can be used safely for ventilation.

**SUPRAGLOTTIC AIRWAY DEVICES**

Certain SGAs can serve as bridges to safe extubation of the difficult airway by allowing uninterrupted airway access, providing oxygenation and ventilation, and
serving as conduits for reintubation. They can be used alone or in combination with AECs and/or a fiber-optic bronchoscope (Figures 1-8). Not all SGAs can be used as extubation bridges, however. The best supraglottic extubation bridge is one designed to function as an intubation conduit in addition to a stand-alone airway device.11 From the limited available literature and our experience, the following devices fit best in this role: The LMA Classic or LMA Unique (Teleflex), Intubating LMA (LMA Fastrach, Teleflex), and the air-Q (Mercury Medical). These SGAs have wide ventilatory tubes that can accommodate a 7.0 internal diameter ETT. They can be railroaded over the existing ETT or placed behind it. They also can be railroaded into position over an existing stylet or exchange catheter, and they allow fiber-optic examination of the airway. Ellard et al reported using an LMA Classic as an extubation bridge after thyroidectomy and tracheal resection in a 75-year-old man who underwent awake TI before anesthesia induction.12 Extubation was desirable to avoid the effects of positive pressure ventilation on the tracheal repair. The LMA provided a route for fiber-optic examination of vocal cord functions. Komasawa et al reported using an air-Q and a tube exchanger as extubation bridges after total maxillectomy in a 79-year-old man.13 The authors inserted the exchanger through the ETT, removed the ETT, then railroaded the SGA over the exchanger. Raveendran et al used an LMA ProSeal and an exchange catheter as extubation bridges after thyroidectomy in a patient who had difficult intubation.14

**Conclusion**

The role of SGAs as extubation bridges in the management of the difficult airway is evolving. The accompanying case scenarios highlight the vital role of the SGAs when used as bridges to safe extubation for high-risk situations.

**Figure 1.** Supraglottic airway placed behind the endotracheal tube before tracheal extubation.

**Figure 2.** Fiber-optic examination of the periglottic area, vocal cords, and trachea through the supraglottic airway.

**Figure 3.** If reintubation is needed, fiberoptic-aided intubation can be swiftly performed through the supraglottic airway.

**Figure 4.** Fiberoptic-aided tracheal reintubation using the air-Q as a conduit.
The anesthesiologist should have a preformulated extubation strategy for the difficult airway and the patient at high risk for extubation. Detection of general and airway risk factors is crucial for stratification of extubation risk and avoidance of postextubation mishaps. The short-term use of a bridging device should be considered for its ability to provide reversibility to the extubation process. Either an airway stylet or catheter, or a supraglottic conduit, can serve this purpose and allow continuous access to the airway after TE. Familiarity with these devices and prior knowledge of their use and limitations is mandatory for patient safety.

References

Figures

Figure 5. Supraglottic airway can be railroaded into position over an existing airway exchange catheter.

Figure 6. A swivel adaptor is used to attach the supraglottic airway to a T-piece or a breathing circuit, while keeping the airway exchange catheter in place.

Figure 7. If reintubation is needed, it can be performed through the supraglottic airway by railroading the endotracheal tube over the airway exchange catheter.

Figure 8. Tracheal reintubation through an air-Q using the airway exchange catheter as a guide.
Case Study 1

A 54-year-old woman was scheduled for a 3-level anterior cervical corpectomy and fusion. The patient had a history of upper extremity weakness and paresis resulting from pathology of her cervical spine that progressively worsened, particularly with neck movement. Awake orotracheal fiber-optic intubation was performed successfully and surgery proceeded. After the 5-hour procedure, a halo vest was placed. At the end of surgery, and with the patient breathing spontaneously, a cuff-leak test was performed that indicated adequate leak. An air-0 was placed behind the orotracheal tube and the trachea was extubated. The patient went to the postanesthesia care unit (PACU) awake, breathing spontaneously, and obeying simple commands with the air-0 in place. The SGA was connected to a T-Piece with oxygen flow of 6 L/minute. Sp02 remained above 97 for 10 minutes, after which it began declining over the next 10 minutes until it reached 90 with no improvement despite increasing the 02 flow rate. A stridorous sound became audible with inspiration. A fiber-optic bronchoscope (FOB) was introduced through the air-0, and examination of the vocal cords revealed bilateral partial adduction. Fiber-optic-aided reintubation was successfully completed in less than 20 seconds. Airway complications after anterior cervical surgery are well reported. An extubation bridge was planned due to the multilevel procedure that lasted for 5 hours.

Recurrent laryngeal nerve injury occurs in 5% of patients who underwent multilevel anterior cervical surgery, causing postoperative respiratory compromise. In this case, cervical spine fusion, pharyngeal edema, and limited access to the airway because of the halo could have made reintubation impossible. The air-0 kept the airway patent during the immediate postoperative period, allowed an uninterrupted airway access, permitted examination of the vocal cords, and facilitated emergency reintubation when the patient’s ventilation was compromised.

Case Study 2

A 55-year-old woman presented with a huge thyroid mass and was scheduled for total thyroidectomy. Computed tomographic scans of the neck and upper chest revealed marked tracheal deviation and retrosternal extension. Awake orotracheal fiber-optic intubation was successfully performed and surgery proceeded. At the end of the procedure, TE was desirable. However, there was some uncertainty regarding left recurrent laryngeal nerve injury and whether the retrosternal tumor had resulted in tracheomalacia. An FOB within an Aintree catheter was advanced through the ETT until its tip emerged from the distal end of the ETT. Airway examination was performed while the ETT was slowly withdrawn after cuff deflation. Fiber-optic examination revealed no abnormalities of the trachea or vocal cords, and it was decided to perform TE but keep an LMA as an extubation bridge during her time in the PACU. The FOB was withdrawn, the catheter was advanced through the cords, and the ETT was removed. An LMA Unique was railroaded in place over the Aintree catheter and the latter was removed. Within 10 minutes, the patient’s oxygen saturation began to decrease gradually, with increasing efforts at both inspiration and expiration. The FOB was introduced through the LMA, and re-examination revealed a collapsing upper tracheal wall-indicating mild tracheomalacia that probably was missed on the brief initial examination.

Tracheomalacia became more evident with increasing inspiratory efforts and increasing the negative intrathoracic pressure. A decision was made to reintubate the trachea to stent open the upper tracheal segment. An ETT was advanced over the FOB and reintubation was successfully accomplished in less than 30 seconds. The FOB and LMA were withdrawn, and the trachea was kept intubated pending further consultation with the thoracic surgeon.

In this case, the FOB allowed initial airway examination as well as reintubation, and the Aintree catheter allowed uninterrupted airway access during the exchange of the ETT and LMA. The LMA allowed access to the airway and served as a route for bronchoscopic examination, as well as a conduit when the decision to reintubate was made based on the examination findings.
Usability and performance characteristics of the pediatric air-Q® intubating laryngeal airway.

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Source

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Abstract

PURPOSE:

The air-Q® intubating laryngeal airway (ILA) is a supraglottic device (SGD) designed specifically to function as both a primary airway and a bridging device and conduit for fibreoptic intubation in difficult airway scenarios. This observational study evaluated the usability and performance characteristics of pediatric air-Q ILA sizes 1.0, 1.5, 2.0, and 2.5 when used as a primary airway.

METHODS:

One hundred ten children, American Society of Anesthesiologists physical status I-III and undergoing elective surgery, received a weight-appropriate air-Q ILA following induction of anesthesia. The evaluation criteria included ease of insertion, quality of ventilation, presence of gastric insufflation, oropharyngeal leak pressures (OLPs) and maximum tidal volumes (VT max) in five different head positions, and fibreoptic view of the glottis.

RESULTS:

For sizes 1.0, 1.5, 2.0, and 2.5, the median [P25,P75] neutral OLPs (cm H2O) were 23.0 [20.0,30.0], 16.5 [15.0,20.8], 14.0 [10.0,17.8], and 14.0 [11.3,16.8], respectively. The median [P25,P75] neutral VT max values (mL · kg(-1)) were 17.4 [14.3,19.7], 20.3 [16.8,25.5], 17.8 [14.5,22.1], and 14.0 [11.6,16.0], respectively. Median [P25,P75] ease of insertion scores (0-10; 0 = easiest ever, 10 = most difficult ever) were 1 [1,2], 2 [2,3], 2 [1,2,8], and 2 [2,3] respectively. Ventilation was adequate in 108/110 cases, and a fibreoptic view of the vocal cords was obtained in 102/110 cases.

CONCLUSIONS:

The air-Q ILA functions acceptably as a primary SGD in infants and children. The OLPs are lower than published values for the ProSeal laryngeal mask airway (LMA ProSeal™), the current pediatric SGD of choice, but adequate tidal volumes are readily achievable. The fibreoptic views of the glottis portend well for fibreoptic intubation through the device. (This trial was registered at clinicaltrials.gov number, NCT00885911)
Utility of the Intubating Laryngeal Airway®: Report of an Observational Study

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Introduction:

The Intubating Laryngeal Airway® (Cookgas Inc, St. Louis, MO) is a new FDA-approved device designed for airway management, or as a conduit for endotracheal intubation. We wished to characterize the utility of the ILA via a non-randomized observational study in a structured series of cases.

Methods:

The Intubating Laryngeal Airway (ILA) was used for airway management in 28 patients scheduled for gynecologic surgery. The ILA was used as a conduit for endotracheal intubation in 22 patients. A fiberoptic bronchoscope (FOB) was passed down the lumen of the ILA following placement to evaluate its relationship to airway structures in the first 20 patients, and to facilitate endotracheal intubation in select patients. Blind passage of an endotracheal tube (ETT) was attempted in 6 of the first 20 patients, and in all of the final 8 patients. In the latter group, the FOB was only used to diagnose obstruction to blind passage (thrice), or to complete failed blind intubation (once).

In 5 patients, extubation was performed under deep anesthesia with the ILA in situ.

All procedures were captured on videotape in the first 20 patients.

Results:

The Intubating Laryngeal Airway was successfully placed on the first attempt in 27/28 patients. A large leak during manual ventilation was corrected in 2 patients by slight withdrawal of the device.

When the FOB was used, the glottis was visualized and the trachea intubated every time. Some degree of epiglottic intrusion was observed on fiberoptic examination in most cases. However, the keyhole-shaped aperture allowed a space for the epiglottis to intrude into, allowing unimpeded ventilation and fiberoptic access to the glottis.

Two cases of malpositioning of the ILA (inserted too deep and laterally displaced respectively), and one case of complete epiglottic downfolding, all without impedance to ventilation, were observed. Epiglottic downfolding was corrected by jaw lift and withdrawal of the ILA, followed by reinsertion (dubbed the "Klein Maneuver").

Under fiberoptic visualization (FOB within lumen of endotracheal tube with no manipulation), a regular endotracheal tube (Mallinckrodt Inc, St. Louis, MO cat. no. 86111) failed to pass directly into the trachea in 3 instances. The more flexible Mallinckrodt Reinforced Tracheal Tube (Mallinckrodt Inc, cat. no. 86552) was advanced directly into the trachea under unguided fiberoptic visualization in 2 of 2 instances. Blind passage of the Mallinckrodt Reinforced Tracheal Tube into the trachea without benefit of a FOB was successful in 8 of 11 instances. In the 8 cases of successful blind passage, 3 passed without jaw lift, and 2 passed following the application of jaw lift. 3 passed on the first attempt following the correction of obstructions to advancement (a downfolded epiglottis, too deep insertion, and lateral displacement of the ILA respectively).

Of the 5 patients extubated under deep anesthesia, the ILA required manipulation to establish airway control in 1 patient, and provided a controlled airway in 4 patients. All 5 patients emerged smoothly from anesthesia without bucking or straining.

Conclusion: The Intubating Laryngeal Airway is effective as a device for airway management, and as a conduit for endotracheal intubation. Optimal techniques for blind intubation, and the utility of the device in difficult airway scenarios, warrants further study.

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