
An Update on Pediatric Airway Management

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The pediatric airway can at times present a challenge to manage and this is particularly true when this skill is infrequently performed.¹ During the past decade, the additions and advancements in airway technology have enhanced our ability to manage the airways of infants and children safely. Indeed, current technology has been a “game changer” in the overall approach to the airway in this patient population. There is no question that the technology is good and continues to get better, but the fact still remains that we must recognize and understand the nuances of the pediatric airway.

Probably one of the best ways to understand how much progress has occurred in pediatric airway management is through the information gained from the ASA Closed Claims Database.^{2,3} Before the 1990s, recurrent findings indicated that the ability to oxygenate or ventilate was the biggest issue.³ However, a more recent review of pediatric anesthesia claims from 1990 to 2000 demonstrated a decreasing trend of respiratory occurrences.⁴

This update will examine features of the pediatric airway, direct laryngoscopy versus videolaryngoscopy, the issue of cuffed versus uncuffed endotracheal tubes (ETTs), and diagnostic techniques for airway assessment. What have we learned about the pediatric airway in the past decade? Without a doubt, what we have learned and the information that we continue to acquire about the pediatric airway should enable us to manage it more safely.

■ The Pediatric Airway: Past and Present

For >50 years, we have been taught that the airway in children below 8 years old is conical in shape, with the narrowest point found

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INTERNATIONAL ANESTHESIOLOGY CLINICS
Volume 55, Number 1, 86–96, DOI:10.1097/AIA.0000000000000132
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at the cricoid ring.⁵ Many of the details regarding the pediatric airway were described by Eckenhoff⁵ in 1951. However, Bayeux⁶ described his findings regarding the pediatric airway in the literature even earlier, just before the turn of the 20th century. Over the years, what has been considered as the traditional teaching with respect to the pediatric airway is actually derived from studies by Bayeux. In these studies, Bayeux⁶ examined cadaveric larynxes of 15 children ranging in age from 4 months to 14 years using plaster castings (moulages).

In more recent years, the traditional teaching about the larynx in infants and children has become a topic of much discussion given the results of newer compared with the older studies.⁷⁻⁹ An important conclusion drawn by Eckenhoff⁵ was that the results obtained with cadaveric larynxes would possibly not be the same when compared with a patient in the clinical scenario. Now, the old as well as new information about the pediatric airway adds another layer of complexity to our concerns about endotracheal intubation. It is important to be familiar with the results of these newer studies.

Litman et al⁷ investigated the laryngeal dimensions in 99 pediatric patients, ranging in age from 2 months to 13 years old. The patients were scheduled for magnetic resonance imaging (MRI) studies under deep sedation with propofol. All of the patients were maintained spontaneously breathing. The authors observed that “the shape of the larynx is conical in the transverse dimension (with the apex of the cone at the level of the vocal cords) and cylindrical in the AP dimension and does not change throughout development”. Of note, the study lacked uniformity as to the point in the respiratory cycle that these observations were made.

Dalal et al⁸ examined the laryngeal dimensions in 128 pediatric patients, 6 months to 13 years old, using videobronchoscopic imaging. The procedure was performed under general anesthesia and included the use of a neuromuscular blocking agent. The results of Dalal et al⁸ indicated that “the glottis was narrower than the cricoid in children from infancy to adolescence. The pediatric larynx is more cylindrical than funnel shaped and an age-based transition from a pediatric funnel shaped to the cylindrical adult larynx was not observed.” Unlike Litman’s study, the laryngeal dimensions measured by Dalal’s group were obtained during a period of apnea.

Wani et al⁹ performed a retrospective review of 220 pediatric patients who ranged in age from 1 month to 10 years undergoing computed tomography (CT) imaging. The scanning of the infants and children occurred under natural sleep or with sedation. The findings by Wani et al⁹ demonstrate that “the cricoid ring is not the narrowest area of the pediatric airway in all dimensions, but the area immediately below the vocal cords is, particularly in the transverse dimension.”

All 3 of these studies share a commonality that point toward the fact that the cricoid ring is not the narrowest part of the pediatric airway. Although more studies are needed in this area, the evidence that is currently available is quite compelling. For those of us who perform endotracheal intubations in infants and children, it is highly recommended that we review the details of these studies.

■ The Pediatric Difficult Airway

The incidence of a pediatric difficult airway is much less when compared with adults.¹⁰ The incidence of difficult intubation in the pediatric population is 0.25% to 3%,¹¹ compared with an incidence of 1.5% to 13% in adults.¹² The difficult airway may be the result of difficult mask ventilation, intubation, or both.

In general, the cause of a difficult airway among patients in the pediatric population is the result of a congenital syndrome or an acquired defect. Most of the difficult airways in these patients will be recognized before the induction of anesthesia. The factors used to predict difficulty with airway management in pediatrics are much less apparent than in adults.¹⁰ Some of the more commonly encountered syndromes that are linked to a difficult airway include Apert syndrome, Beckwith-Wiedemann syndrome, Crouzon syndrome, Down syndrome, Goldenhar syndrome, Klippel-Feil sequence, Pfeiffer syndrome, Pierre Robin sequence, and Treacher Collins syndrome.

Heinrich et al¹³ present retrospective data from 11,219 anesthetics in pediatric patients to determine the incidence and clinical characteristics that might be associated with difficult laryngoscopy. The findings suggest that additional risk factors may need to be considered with difficult intubation. These investigators describe risk factors for difficult intubation as age below 1 year old, malnourished, and those patients classified as ASA physical status III or IV. The study identified a subset of pediatric patients who previously may not have been considered as part of the “at-risk group” for difficult intubation.

Less than a decade ago, the Pediatric Difficult Intubation (PeDI) registry was formed in an effort to team up a number of hospital centers to focus on concerns of quality improvement in patients with difficult endotracheal intubation. The PeDI registry evolved as a special interest group from the Society for Pediatric Anesthesia. Initial steps were taken by the group to make uniform airway-related terminology, data collection, and outcome measures.¹⁴ Before the PeDI registry, there was no database that provided the complications associated with difficult endotracheal intubation. Fiadjoe et al¹⁴ present data on 1018 difficult pediatric endotracheal intubations. The registry indicates that the technique used most commonly for endotracheal intubation is direct

laryngoscopy, followed by fiberoptic bronchoscopy, and then videolaryngoscopy. The events with the highest incidence are cardiac arrest and temporary hypoxemia. Most interesting are the findings that suggest that >2 attempts at securing the airway with direct laryngoscopy and an apparent difficult endotracheal intubation are associated with a greater chance of unsuccessful intubation and life-threatening events.

A key element in managing a pediatric difficult airway is the implementation of a systematic approach to the airway. The Paediatric Airway Guidelines Group of the Difficult Airway Society published 3 algorithms that underscore areas of greatest challenge in the unanticipated difficult airway in children aged 1 to 8 years: difficult mask ventilation, unanticipated difficult tracheal intubation, and cannot intubate and cannot ventilate (Figs. 1–3).¹⁵

■ Direct Laryngoscopy Versus Videolaryngoscopy

Anesthesia providers have the knowledge and skill necessary for direct laryngoscopy. During the past decade, videolaryngoscopy has been receiving a great deal of attention as an airway device for use in the pediatric patient.^{16–20} For some anesthesiologists, the use of videolaryngoscopy has become quite commonplace, and it is viewed as a viable alternative to direct laryngoscopy. In contrast, some laryngoscopists prefer to use videolaryngoscopy only in the case of a difficult airway. The use of videolaryngoscopy has made a significant impact in overall airway management.

We have witnessed over the past ≥ 10 years the introduction of a number of videolaryngoscopes for use not only in adults but also in pediatric patients. Many of these devices have a laryngoscope size that can accommodate the smallest airways of premature infants and neonates. Videolaryngoscopy offers an expanded view of the airway as compared with direct laryngoscopy, allowing for a more complete assessment of the airway.²¹ In addition, the quality of the image obtained with videolaryngoscopy is quite defined and detailed. These features combine to make the use of videolaryngoscopy very appealing.

A review of all the videolaryngoscopes currently available on the market is beyond the scope of this article. Of note, most of the literature citing the use of videolaryngoscopy in the pediatric population is linked to the GlideScope.^{16,22–28} To date, Kim et al²³ have performed the largest study in pediatric patients using the GlideScope. The results of their study demonstrated that the GlideScope offered similar or improved views of the larynx compared with the conventional laryngoscope,²³ although the time to complete the intubation was greater with the GlideScope.²³ Redel et al²⁵ examined the use of the GlideScope videolaryngoscope and the Macintosh laryngoscope in a

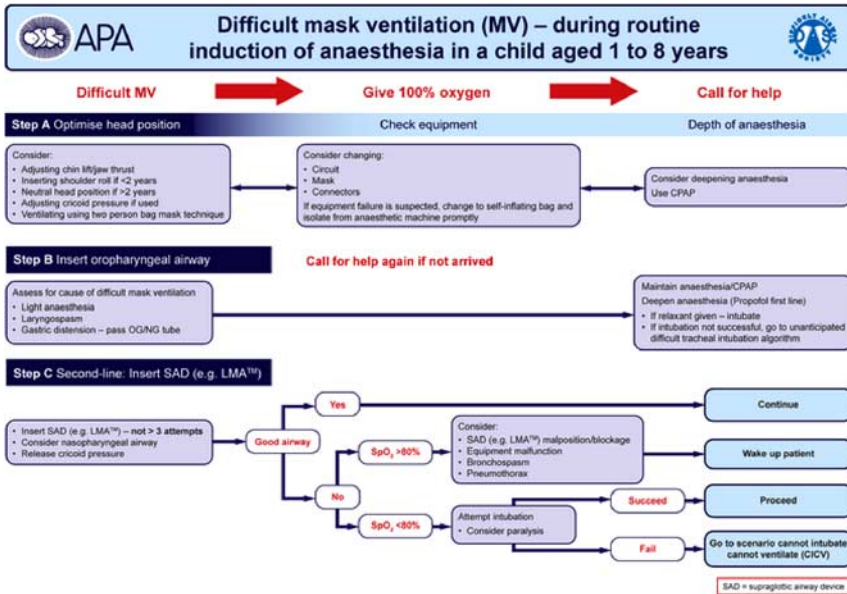


Figure 1. Guidelines for the management of difficult mask ventilation in a child. Reproduced from APAGBI Paediatric Difficult Airway Guidelines 2015. Paediatric Airway Guidelines Group. 

group of pediatric patients. The conclusion of the investigation was a similar duration of time to intubate as well as similar occurrence of airway trauma between these 2 devices.²⁵

■ Uncuffed Versus Cuffed Endotracheal Tubes (ETTs)

For the past decade or more, there has been an ongoing discussion about the use of uncuffed versus cuffed ETTs in infants and children aged below 8 years. Conventional teaching in pediatric anesthesia has recommended the use of an uncuffed tube for several reasons. First, this training is based on the assumption that the cricoid ring is the narrowest part of the airway until the age of 8 years.⁵ More recent research might suggest that this is not the case.^{7–9} Second, the belief has been held that the uncuffed ETT conforms to the shape of the cricoid cartilage and provides an adequate seal.²⁹ There is sufficient evidence in the literature to demonstrate the fact that uncuffed ETTs are not without the potential for causing subglottic damage in the pediatric airway.³⁰ Finally, the idea has existed for quite some time that cuffed ETTs were linked to more airway injury than uncuffed tubes.³¹

What does the airway evidence imply with regard to the use of an uncuffed or cuffed ETT in children aged below 8 years? One area of concern with the use of an ETT below 8 years of age is the need for the

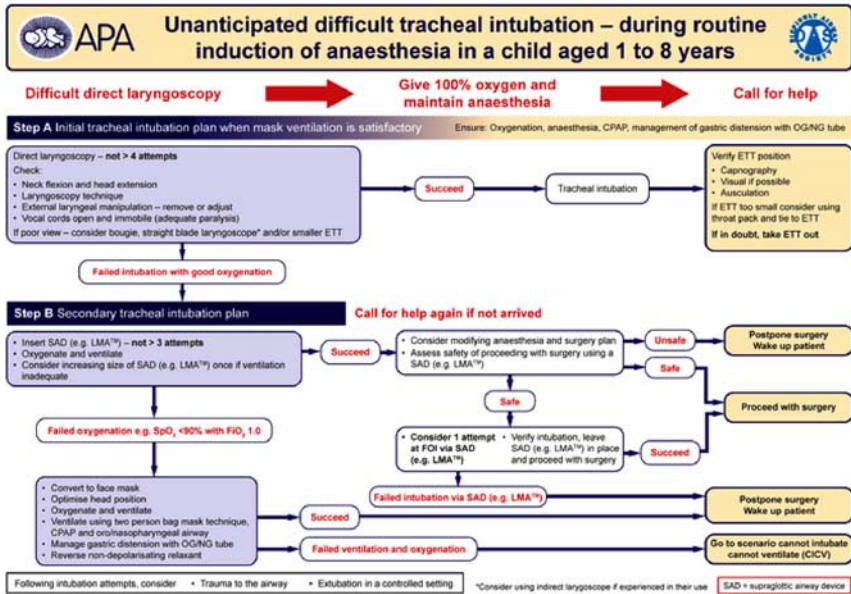


Figure 2. Guidelines for the management of unanticipated difficult tracheal intubation in a child. Reproduced from APAGBI Paediatric Difficult Airway Guidelines 2015. Paediatric Airway Guidelines Group. [full color online](#)

presence of a small air leak around the tube. With an uncuffed ETT, the leak may be very large, very small, or not present at all. Although the same air leak scenarios could occur with a cuffed ETT, the need to exchange the tube appears less. It is important to keep in mind that tube exchange is not without potential for injury to the airway. The most crucial area in the airway for pressure created by the presence of an ETT is posterolateral.³⁰

Cuff pressure, although not an obvious concern with an uncuffed tube, should be closely monitored to avoid trauma to the airway in the presence of a cuffed ETT. In recent years, the need to monitor the intracuff pressure has been more widely discussed in the literature. Despite the concern for a potentially high intracuff pressure, the use of a cuffed ETT in a young child does not appear to put the airway at an increased risk of damage.³⁰

In less than a decade, there has been a drastic shift toward the use of cuffed ETTs in pediatric anesthesia. Indeed, there are apparent benefits to the use of a cuffed ETT. First, the ability to ventilate and oxygenate seems more predictable with a cuffed tube.³² Next, the presence of a cuffed ETT significantly minimizes contamination of the upper airway by inhalation anesthetic agents.³³ Finally, Calder et al³⁴ investigated the incidence of sore throat in a group of 500 pediatric patients, ranging in age from 3 to 16 years. The result of their investigation concluded that

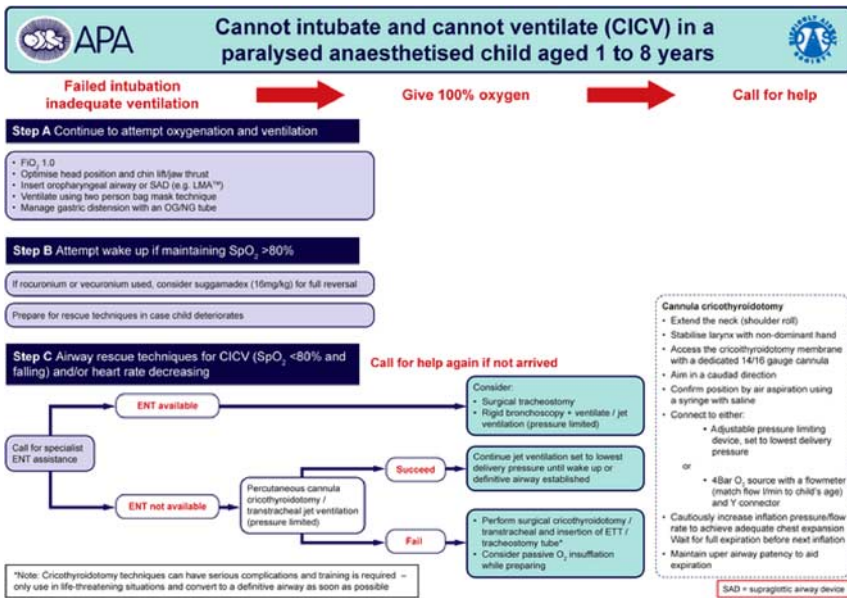


Figure 3. Guidelines for the management of cannot intubate and cannot ventilate in a child. Reproduced from APAGBI Paediatric Difficult Airway Guidelines 2015. Paediatric Airway Guidelines Group. [full color online](#)

there is about twice the incidence of sore throat with an uncuffed compared with a cuffed ETT (37% vs. 19%).

■ Diagnostic Techniques for Airway Assessment

MRI and CT scan are diagnostic imaging modalities that are often used to assess the airway. Typically, when diagnostic imaging is used for an assessment of the airway, it has already been requested by our surgical colleague. For the most part, as anesthesiologists we rely on our clinical skills to assess the airway of our patient. In infants and young children, this is not always easily accomplished due to a lack of cooperation. MRI is a noninvasive diagnostic procedure that offers the distinct advantage over CT scan of using nonionizing radiation. Both MRI and CT scan are used as diagnostic tools for airway assessment in pediatrics.^{7,9} However, MRI tends to offer superior soft-tissue contrast and can create images through any body plane.³⁵

For the anesthesiologist, the use of ultrasound should be considered as an imaging technique for airway assessment. In the operating room, ultrasound has garnered a great deal of attention due to its use in regional blocks and central and peripheral venous access, and so for many anesthesiologists, the ultrasound is already part of our armamentarium. Singh et al³⁶ examined the utility of sonography for

adult airway assessment, and concluded that comprehensive features of the upper airway could be obtained. The airway anatomy visualized with this technique included the epiglottis, thyroid cartilage, cricoid cartilage, tracheal rings, and vocal cords. In contrast, there is a paucity of data regarding the use of ultrasound for the assessment of the pediatric airway. The literature that is available on the use of ultrasound in the pediatric airway seems quite promising as a technique with good utility.^{37,38}

■ Rapid Sequence Induction

The past decade has also witnessed a continuation of the controversial discussion surrounding the use of rapid sequence induction and intubation (RSII) in pediatric patients. For the most part, there are 2 different approaches to RSII that have been described in the anesthesia literature.^{39–41} Anesthesiologists as well as other specialists utilize these approaches in their rapid sequence technique to secure the pediatric airway.^{42,43} For example, in the pediatric emergency medicine literature, the same technique is termed rapid sequence intubation (RSI).^{43,44} That said, the premise for both RSII and RSI is that they provide a means to protect the lungs against the aspiration of gastric contents in patients considered to be at risk for a full stomach.

The hallmarks of RSII and RSI have always included preoxygenation with 100% oxygen for several minutes, followed by the use of cricoid pressure as loss of consciousness occurs after a rapidly administered intravenous hypnotic agent and depolarizing neuromuscular blocking agent.⁴⁴ The question regarding the suitability of the use of traditional RSII in pediatric patients has been gaining more scrutiny in the anesthesia literature.⁴⁵ The risk of gastric regurgitation and pulmonary aspiration has always been linked to the patient presenting with a full stomach. However, there is also reason for concern regarding possible hypoxemia, cardiovascular perturbations, and difficult ventilation and/or intubation associated with the traditional approach to RSII.⁴⁶

The updated approach to the management of the pediatric patient at risk for aspiration of gastric contents requiring general anesthesia has more recently been described as a “controlled rapid sequence induction and intubation” (cRSII).^{41,47} Essentially, the latter approach mimics that of a standard intravenous induction. The cRSII approach involves the induction of anesthesia with a hypnotic agent followed by a non-depolarizing neuromuscular blocking agent. Lightly performed mask ventilation occurs before intubation, and the use of cricoid pressure is not advised.⁴⁷ To date, there is limited evidence citing the use of cRSII in pediatric patients.⁴⁷ The largest study on the use of cRSII by Neuhaus

et al⁴⁷ included 1001 children. The investigators concluded that the use of cRSII provided no untoward conditions for intubation in the pediatric patient undergoing general anesthesia with a full stomach.

The contraindications associated with the use of succinylcholine in pediatric patients for RSII have not changed. As a historical background, in the early 1990s the use of succinylcholine gained a great deal of scrutiny secondary to reports of hyperkalemic cardiac arrest in children.^{48,49} A number of these cases were later linked to male children with muscular dystrophy.⁴⁸ These clinical cases exemplify the need to avoid succinylcholine in children with a possible undiagnosed muscle disorder and muscular or myopathic dystrophy.

■ Summary

In conclusion, this update focuses on several issues of ongoing discussion related to the pediatric airway and its management. During the past decade, our understanding of the pediatric airway has evolved. Possibly, one of the biggest changes associated with the pediatric airway is alteration of a long-held tenet of our anesthesia training. For >50 years, the cricoid ring has been considered as the narrowest point in the pediatric airway. This seems less likely with the latest research. There is a continuing need for studies to evaluate the pediatric airway. In addition, some approaches currently in use by the laryngoscopist may need rethinking. At least for now, anesthesiologists managing the airway of a pediatric patient should be cognizant of these newer findings.

The author declares that there is nothing to disclose.

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