Abstract:
Most pediatric intubations that occur in the emergency department are in patients without identifiable risk factors for difficulty. Infants and children go through a predictable pattern of development that impacts airway management. A careful, stepwise approach to the identification of the truly difficult pediatric airway is critical to avoid morbidity and mortality. Difficulty can be encountered in cases of challenging anatomy such as congenital airway or midface abnormalities or with acquired conditions such as croup or epiglottitis. Physiologically, intrinsic lung disease (ie, asthma) and shock states have unique features that impact airway management.

Keywords:
intubation; pediatric; anatomy; physiology; difficult airway

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Airway Management in Patients With Abnormal Anatomy or Challenging Physiology

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Successful airway management in the emergency department (ED) requires a stepwise, rigorous approach in order to identify and mitigate risk factors for difficulty. These risk factors, including such things as trauma, obesity, and malignancy, are relatively more common in the adult population than in children. Airway management in children is predictably different, both anatomically and physiologically, than in the adult population, but not inherently difficult in most cases. These anatomic and physiologic differences are most pronounced in the first 2 years of age, during which most of the normal developmental changes in airway structures occur.

Difficulty in pediatric airway management can occur in the rare case of anatomic disruption from either infection or trauma, congenital malformations that affect the airway structures, or more commonly when dealing with the physiologic stresses resulting from acute illness. Careful attention to maximizing preintubation conditions and developing a structured approach to the identification of the potentially difficult airway maximizes the likelihood of successful intubation.

NORMAL ANATOMIC AND PHYSIOLOGIC DEVELOPMENT

Anatomic Considerations

There are several distinct anatomic and physiologic differences that impact airway management in the young infant and child. These differences are most distinct in the first 2 years of life, while children aged 2 to 8 years are transitioning to more adult-like anatomy and physiology. Anatomically, infants have a relatively large occiput in relation to their body size. This impacts optimal positioning for airway management as an infant lying prone on a stretcher will actually be in slight flexion at the neck owing to the size of the occiput. This can make it challenging to optimally align the oral, pharyngeal, and laryngeal axes for direct laryngoscopy. A line drawn horizontally through the external auditory canal should pass just anterior to the shoulder and be parallel to the bed in a patient who is positioned correctly for intubation (Figure 1). A towel roll placed under the shoulders of a small infant can be used to overcome the large occiput and should be used for optimal positioning. Older infants and children (age, 6 months to 5 years) most often need no support, whereas adolescents and adults may require head support to achieve appropriate positioning prior to intubation.

Small children also have relatively large tongues in relation to their oral cavity and a large floppy epiglottis which can impact visualization of airway structures during direct laryngoscopy. The large tongue predisposes the child to obstruction when sedated or obtunded, although this can be mitigated by the use of an appropriately sized oral or nasal airway. Similarly, direct manipulation of the epiglottis using a straight (Miller) blade is often required to achieve visualization of the vocal cords. Children also have larger, more vascular tonsillar and adenoidal tissue which is prone to bleeding with manipulation during airway procedures and can lead to partial airway obstruction with decreased levels of consciousness.

The vocal cords are at the level of the first cervical vertebrae in infants and drop to the C3-4 level by age 7 years before attaining their adult position near C6 by late adolescence. This normal developmental pattern impacts endotracheal intubation as the airway structures in infants and younger children will appear "higher and more anterior" than those in an older adolescent or adult, although again this can be mitigated by meticulous attention to preprocedure positioning.

Anatomically, the narrowest fixed portion of the pediatric airway is subglottic at the level of the cricoid ring. Historically, the pediatric trachea has been described as "conical" rather than cylindrical which has led to the common practice of placing uncuffed endotracheal tubes during intubation. More recent literature examining airway anatomy in anesthetized pediatric patients by bronchoscopy or magnetic resonance imaging suggests that the airway may be less conical than previously believed, with the subglottic region actually shaped like an ellipse.[1–3] Thus, although uncuffed tubes are perfectly acceptable, cuffed endotracheal tubes are considered equally safe to use based on randomized trials and current Pediatric Advanced Life Support recommendations, in cases where high airway pressures (ie, asthma, acute respiratory distress syndrome, multifocal pneumonia) or changing compliance is anticipated, or when aspiration is a risk.[4,5] Pediatric cuffed endotracheal tubes are now made with the ability to carefully manage cuff pressure with a cuff manometer or by auscultating for air leak which lessens the likelihood of cuff overinflation and damage to the subglottic structures. The pediatric trachea is also more prone to dynamic collapse during periods of agitation or partial airway obstruction (ie, croup). The flexibility of the upper airway can result in "complete" collapse without complete obstruction. Positive pressure, such as that provided by bag-valve-mask (BVM) ventilation can stent open a partially obstructed upper airway and should be considered the initial rescue technique of choice in these cases.

Although exceedingly rare in clinical practice, pediatric airway management at times calls for the placement of a surgical airway. The cricothyroid membrane in children younger than 10 years is exceedingly small and open surgical cricothyroidotomy is not recommended as a rescue technique. In these small children, needle cricothyroidotomy should be considered as an alternative. This technique has been studied in animal models and allows for oxygenation for a defined period (a minimum of 30 minutes based on dog models), during which definitive airway control can be attained.[6,7]

Physiologic Considerations

Infants and small children have a high metabolic rate and lower functional residual capacity when compared with adults. Thus, desaturation can occur in a much more precipitous and rapid fashion even with appropriate preoxygenation during airway management. A fully preoxygenated adult patient with healthy lungs will not desaturate below 90% with apnea for as long as 6 minutes. A normal, healthy 10-kg child who is fully