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November 2017
Volume 14, Number 11

Management of Airway Obstruction and Stridor in Pediatric Patients

Abstract

Stridor is a result of turbulent air-flow through the trachea from upper airway obstruction, and although in children it is often due to croup, it can also be caused by noninfectious and/or congenital conditions as well as life-threatening etiologies. The history and physical examination guide initial management, which includes reduction of airway inflammation, treatment of bacterial infection, and, less often, imaging, emergent airway stabilization, or surgical management. This issue discusses the most common as well as the life-threatening etiologies of acute and chronic stridor and its management in the emergency department.

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Case Presentations

A 20-month-old boy is brought into the ED by his mother who is concerned because he woke up with a barking cough and he sounded like he was having difficulty breathing. Prior to tonight, he had 2 days of fever and a runny nose. The mother states that her son's voice sounds more hoarse than usual. The boy's vital signs are notable for a fever of 39.2°C (102.6°F), a respiratory rate of 60 breaths/min, and a pulse oximetry reading of 98% on room air. He is not in significant acute distress when you walk into the room, but you immediately notice inspiratory stridor at rest, and subcostal retractions. The physical examination is otherwise notable for clear rhinorrhea and transmitted upper airway sounds in the lungs. The nurse asks if you would like to order urgent medications or imaging. Do you give racemic epinephrine and/or dexamethasone immediately? Is a chest x-ray necessary? How long should you observe this patient before deciding on his disposition?

A few minutes later, EMS brings in a 4-year-old boy for stridor and drooling. Per the paramedics' report, he's had 6 days of rhinorrhea and cough, followed by fever for the past 2 days. Tonight, his mother called 911 when he started drooling at the dinner table and would not participate in the family's conversation. On EMS arrival, he is febrile to 40°C (104°F), his respiratory rate is 44 breaths/min, and he has a pulse oximetry reading of 92% on room air. The EMS team started supplemental oxygen via facemask and attempted to place a peripheral IV catheter, without success. On ED arrival, the boy is sitting up on the stretcher, unwilling to move. You ask him his name, but he just looks at you and doesn't answer. The collar of his shirt is wet from drooling, and he looks afraid. At this point, what initial steps should be taken? Should you make another attempt to obtain IV access? Is imaging necessary?

Near the end of your shift, a 3-month-old girl is brought into the ED by her parents for noisy breathing while feeding tonight. She was born at 34 weeks and has had several visits to her pediatrician for intermittent stridor and noisy breathing that started approximately 1 month after birth. She has been treated multiple times for croup over the past 4 weeks. On examination, she is very active and well-appearing, with intermittent stridor. She has no retractions or tachypnea, and her vital signs are all within normal limits. What additional questions on history would aid in making the diagnosis? How will you confirm a diagnosis in this patient? Is imaging useful in this scenario?

Introduction

Respiratory distress is one of the most common reasons children present to the emergency department (ED), accounting for 10% of visits.¹ Life-threatening airway emergencies are often secondary to obstruction and must be recognized quickly.

Upper airway obstruction in children can range from partial to complete, and often presents with stridor, a high-pitched breath sound produced by turbulent air-flow through a partially obstructed airway. Stridor can be acute or chronic, and acquired or congenital. Because stridor is a sign and not a diagnosis, the underlying etiology must be identified to guide management.^{2,3} In the ED, identifying severe and life-threatening causes of stridor and acting quickly are crucial to preventing respiratory failure.

The cause of upper airway obstruction can often be identified through history and physical examination alone. The age of the child is an important consideration. While chronic and congenital etiologies of stridor are more common in neonates and infants aged < 6 months, acute infectious etiologies are more prevalent in older infants and children.⁴ The most common cause of acute stridor in children presenting to the ED is croup; the most common cause of chronic stridor is laryngomalacia.^{5,6}

The management of upper airway obstructions continues to evolve. The development of the *Haemophilus influenzae* type B (Hib) vaccine has greatly reduced the number of cases of *H influenzae* type B epiglottitis. Increased knowledge regarding intubation of neonates has led to a dramatic decline in acquired subglottic stenosis, and technological advances in endoscopic airway visualization have revolutionized surgical management of pediatric airways.⁷

This issue of *Pediatric Emergency Medicine Practice* focuses on the etiology, diagnosis, and management of upper airway obstruction in the ED, specifically, the most common and life-threatening etiologies of acute and chronic stridor. Prompt recognition and appropriate treatment of stridor in the ED are key to recovery for children with upper airway obstruction.

Critical Appraisal of the Literature

A literature search was performed in PubMed using the terms *stridor*, *upper airway obstruction*, *croup*, *epiglottitis*, *bacterial tracheitis*, *mononucleosis*, *foreign body*, *anaphylaxis*, *biphasic reaction*, *airway burns*, *thermal burns*, *laryngomalacia*, *subglottic stenosis*, *vocal cord paralysis*, *vocal cord dysfunction*, *respiratory papilloma*, *subglottic hemangioma*, *vascular rings*, and *bronchogenic cysts*. The search was filtered for patients aged 0 to 18 years. A total of 193 articles published from 1988 to the present were reviewed. The Cochrane Database of Systemic Reviews was searched using the terms *stridor* and *upper airway obstruction*; 14 reviews were identified, with 3 of them pertinent to this article. The American Academy of Pediatrics (AAP) and National Guideline Clearinghouse (www.guideline.gov) were also searched, but there are no official guidelines or clinical algorithms

relevant to the scope of this article.

The majority of studies on stridor are retrospective chart reviews, with very few randomized controlled trials or prospective studies. Much of the focus on newer research on stridor and upper airway obstruction has been on the treatment of croup with steroids and nebulized epinephrine. Because many acute causes of stridor—especially those that are life-threatening—are rare in pediatric patients, many of the articles on these topics consist of case reports and case series. High-quality pediatric studies are still needed on the topic of upper airway obstruction, as many clinical questions remain unanswered.

Anatomy and Pathophysiology

As a result of their unique anatomy and physiology, children are more likely than adults to experience acute airway obstruction. According to Poiseuille's law, resistance is proportional to the fourth power of the radius with laminar flow and estimated to be proportional to the fifth power of the radius with turbulent flow, as in cases of stridor.⁸ (See Figure 1.) For this reason, stridor may present only when a child is crying or agitated and turbulent flow through the airway is present.

Anatomical differences between children and adults also contribute to the increased frequency of stridor occurrence in pediatric patients. While it was once thought that the narrowest part of a pediatric airway was at the cricoid cartilage, recent studies have shown that the glottic and subglottic areas are narrower than the cricoid area in children.^{4,9-11} The neonatal airway is, on average, 4 mm at its smallest diameter; thus, even 1 mm of inflammation results in significant obstruction of the airway.^{12,13} (See Figure 1.) In addition, the submucosa at the level of the cricoid is rich in mucous glands, making an inflammatory trigger in that area especially prone to causing obstruction. Children also have larger tongues relative to the size of their oral cavity and

Figure 1. Airway Diameter and the Effect of Edema on Resistance in Infants and Adults

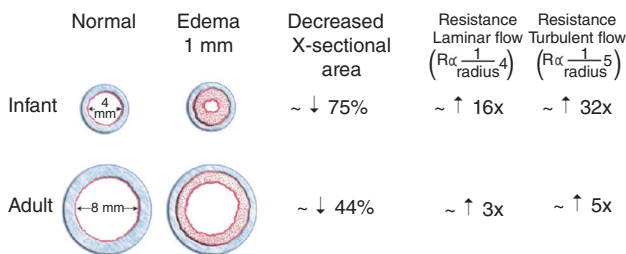


Image to scale when printed at page size 8.5 x 11 in. Reprinted from *A Practice of Anesthesia for Infants and Children*, 4th Ed, Melissa Wheeler, Charles J. Coté, and I. David Todres, The Pediatric Airway, pages 237-278, © 2009, with permission from Elsevier.

a broader and longer epiglottis, making it more difficult to move air past an obstruction. In addition, the larynx is more anterior and superior, more compliant, and less fibrous in children than in adults, making compression more common in children.¹² Children have weaker and less fibrous diaphragms, decreased mechanical efficiency of the chest wall secondary to increased compliance, and immature accessory muscles, resulting in quicker deterioration and decreased respiratory reserve once obstruction occurs.¹⁴ For all of these reasons, emergency clinicians must be especially vigilant when managing stridor in children.

Stridor can be inspiratory, expiratory, or biphasic, which can help identify the anatomical area of concern. In children, inspiratory stridor is most common, as the negative intraluminal pressure during inspiration more easily causes collapse of the airway.^{3,15} Extrathoracic lesions (above the level of the vocal cords) most often result in inspiratory stridor, whereas intrathoracic lesions cause expiratory stridor.⁸ Biphasic stridor suggests a fixed obstruction at or below the level of the glottis or subglottis and may represent progression of disease.^{14,16}

Etiology and Epidemiology

Croup

Acute stridor in children is most often secondary to an infectious etiology, with croup being the most common cause. It is estimated that croup is the cause of 15% of respiratory tract infections in children.¹⁷ Croup primarily affects children aged 6 months to 3 years, with a peak annual incidence of 5% at 2 years of age. Boys are approximately 1.5 times more likely to be affected by croup than girls. Most cases of croup are viral, with parainfluenza 1 and 3 being the most common agents; however, a variety of viruses have been identified, including influenza A.⁵ Of those children presenting to the ED with croup, approximately 8% will be admitted to the hospital and < 1% will be admitted to the intensive care unit (ICU).¹⁸

Epiglottitis

The epidemiology and etiology of epiglottitis has changed greatly since the development of the Hib vaccine in the early 1990s. Prior to the vaccine, *H influenzae* type B was the most common cause of epiglottitis, responsible for 85% of cases.¹⁹ Now, however, the incidence of epiglottitis has decreased dramatically, and there are a variety of organisms noted in cases of epiglottitis, including nontypeable *H influenzae*, *Haemophilus parainfluenzae*, *Staphylococcus aureus*, group A beta hemolytic streptococci, and *Streptococcus pneumoniae*.²⁰ These changes may also be influencing the average age of patients who present with epiglottitis. A 2004 single-center chart

review noted a shift in the average age of patients from 5.6 years in the early 1990s to 14.6 years by 2002.²¹ A 2009 study using the Kids' Inpatient Database found the average age of patients to be 4.3 years, with 63% of children aged < 2 years.²²

Bacterial Tracheitis

Bacterial tracheitis has a slightly different etiologic profile, with the most commonly isolated organism being *S aureus*, co-infected with *S pneumoniae*, group A streptococci, *Moraxella catarrhalis*, or *H influenzae*.²³

Differential Diagnosis

Acute stridor can be differentiated into infectious and noninfectious etiologies. (See Table 1.) Infectious etiologies range from mild and self-limiting to life-threatening causes that require immediate intervention. Acute infectious causes include croup, bacterial tracheitis, epiglottitis, retropharyngeal and peritonsillar abscesses, and mononucleosis. Noninfectious causes include foreign body aspiration, anaphylaxis, airway burns, and vocal cord dysfunction. Chronic stridor usually occurs secondary to congenital conditions, but can also be acquired. Sometimes obstruction from congenital conditions is present at birth, but does not manifest as stridor initially, resulting in delayed presentation.²⁴ These conditions include laryngomalacia, subglottic stenosis, vascular rings, and subglottic cysts. Neoplasms and extrinsic compression of the airway by diseases such as respiratory papilloma, subglottic hemangioma, and neck masses also result in stridor and should be considered when assessing stridor and upper airway obstruction.

Prehospital Care

During the initial evaluation, airway sounds (eg, stridor, wheezing, snoring) must be differentiated. (For audio of various breath sounds, go to: <https://www.practicalclinicalskills.com/breath-sounds-reference-guide/>.) Stridor is a high-pitched sound most commonly heard on inspiration, and, in most cases, can be heard without a stethoscope. Wheezing is most often heard on expiration, and auscultation typically requires a stethoscope. Careful observation of the phases of respiration is necessary to differentiate inspiratory and expiratory sounds. Stertor (snoring) is a low-pitched sound, and is most commonly heard with nasal or nasopharyngeal obstruction. Parents often mislabel these airway sounds, so information from witnessing prehospital providers should be elicited if the patient has improved en route.³

The goal of prehospital providers is to maintain airway patency until arrival at a higher level of care. Providers should utilize caregivers for support and

comfort. Children should be kept calm to prevent turbulent airflow and the precipitation of airway compromise.¹³ Therefore, unnecessary procedures should be avoided (eg, intravenous line placement, supplemental oxygen, or putting anything into the mouth of the patient in an attempt at visualization). If oxygen is necessary, "blow-by" is often the best choice, as a mask or nasal cannula on the face is often distressing for a child.²⁵ Children should be allowed to maintain positions of comfort, which may include sitting upright or in a tripod position. This will help minimize anxiety and airway obstruction.⁸ If there is a history suggestive of anaphylaxis, intramuscular epinephrine should be delivered promptly and can be accomplished with the patient's autoinjector, if available.

Table 1. Differential Diagnosis of Stridor

Acute Infectious Etiologies

- Croup
- Epiglottitis
- Tracheitis
- Mononucleosis
- Retropharyngeal abscess
- Peritonsillar abscess
- Diphtheria
- Tonsillitis
- Ludwig angina

Acute Noninfectious Etiologies

- Foreign body
- Anaphylaxis
- Angioedema
- Airway burns
- Vocal cord motion impairment
- Hypocalcemia
- Laryngeal fracture
- Laryngospasm

Nonneoplastic Chronic Etiologies

- Laryngomalacia
- Tracheomalacia
- Subglottic stenosis
- Tracheal stenosis
- Vascular ring/sling
- Bronchogenic cysts
- Laryngeal web
- Lingual thyroglossal duct cyst
- Lingual thyroid
- Craniofacial syndromes with associated macroglossia, micrognathia
- Laryngeal cleft

Neoplastic (Malignant or Benign) Etiologies

- Neck mass
- Subglottic hemangioma
- Respiratory papilloma
- Cystic hygroma
- Lymphadenopathy/lymphoma
- Mediastinal mass

In the case of complete upper airway obstruction, such as in the setting of suspected foreign body aspiration, basic life-support maneuvers such as back blows in a head-dependent position and chest thrusts (for infants) or abdominal thrusts (for older children) are indicated. Patients with a suspected foreign body who have stridor but are maintaining their airway should be kept comfortable en route. Minimal intervention should be performed, to prevent dislodgement of a partially obstructive foreign body to full obstruction.

During transport, all children with stridor should be monitored for hypoxemia and fatigue. If complete airway obstruction or signs of respiratory failure are imminent, rapid transport to the nearest ED and preparations for possible endotracheal intubation or needle or surgical cricothyrotomy should be made.

Emergency Department Evaluation

History

Patient Age

The age of the patient, by itself, can guide decision-making when it comes to differential diagnosis. For example, croup is the most common cause of infectious stridor and is most prevalent in children aged 6 to 36 months. The highest risk for foreign body aspiration is in young children aged 1 to 3 years.^{26,27} Bacterial tracheitis is most commonly seen in children aged 6 months to 14 years, with peak occurrence between ages 3 and 8 years.²⁸ While retropharyngeal abscess is more common in younger children, peritonsillar abscess is more common in adolescents. Similarly, mononucleosis is more prevalent among school-aged children and adolescents. Laryngomalacia, the most common cause of chronic stridor, typically presents at 2 weeks of age and resolves by 18 months.²⁹

Timing and Onset of Symptoms

Other important considerations include timing and onset of symptoms. Acute-onset stridor in the setting of fever makes infectious etiologies such as croup, tracheitis, or epiglottitis most likely. The onset of bacterial tracheitis usually occurs over 2 to 5 days, as it is often a secondary bacterial infection, unlike croup, which is usually viral in origin and has an abrupt onset.¹³ While epiglottitis and tracheitis both commonly present with fever and respiratory distress, epiglottitis often has a more rapid, abrupt onset than tracheitis.^{19,30} Of the acute etiologies of stridor, deep neck infections typically have the slowest onset of symptoms, as the infection often progresses through several stages prior to development of an abscess that results in stridor.³¹ Recurrent stridor with gradual onset is most suggestive of chronic etiologies of stridor (eg, laryngomalacia, vocal cord paralysis, and tracheal stenosis).

Precipitating Events

Precipitating events (eg, infection, prior head or neck trauma, a history of procedures, feeding or body position, or the presence of fever) can provide clues to the possible etiology of stridor.¹⁶ For example, stridor associated with croup is typically worse at night and preceded by an upper respiratory infection, whereas stridor associated with laryngomalacia may be noticeably worse with feeding and associated with poor growth. Epiglottitis and bacterial tracheitis are both often preceded by fever, with a toxic-appearing child; however, epiglottitis often has a more acute onset of symptoms. Deep neck infections are often precipitated by pharyngitis and/or tonsillitis. When considering chronic etiologies, a thorough birth history should be taken, including feeding and respiratory difficulties, prior intubations, and any intensive care hospital courses.⁴ A history of prior intubation can suggest possible acquired tracheal stenosis, whereas birth trauma or forceps delivery can lead to vocal cord paralysis as a likely etiology of persistent stridor.¹⁶

Physical Examination

Initial Evaluation

During the initial evaluation of a child with stridor, observation is crucial. First, determine the degree of respiratory distress and whether immediate intervention is necessary; general appearance, level of consciousness, and posture are quick indicators of the degree of distress. If the child is unstable and there is concern for impending respiratory failure, minimal manipulation and interventions are key to keeping the airway patent until all steps are in place for acute intervention.

Tachypnea, retractions, nasal flaring, and accessory muscle usage in the setting of upper airway obstruction should be monitored closely. A change in the level of consciousness, hypoxia, or hypercapnia can be indications of fatigue. In children with fluctuations in their level of consciousness, a blood gas test should be obtained to assess for hypercapnia and the need for increasing ventilatory support. If a child is sitting in a tripod position, this is suggestive of significant respiratory distress and possible epiglottitis, and preparations for airway stabilization should be made. Children aged < 2 years often require more aggressive airway management with intubation, whereas older children can initially be treated more conservatively with noninvasive ventilation, as needed, and supportive care.²² While children with retropharyngeal abscesses will often hyperextend their neck for comfort, children with peritonsillar abscesses may present with trismus and difficulty speaking and swallowing.

Evaluation of voice quality, craniofacial abnormalities, exacerbating factors, and ability to manage secretions can also provide further information regarding the etiology of stridor. Anaphylaxis may

present with hoarseness of the voice in addition to other signs of an allergic reaction, indicating an immediate need for intramuscular epinephrine. A child presenting with stridor and a weak cry can be indicative of vocal cord paralysis. In cases of stridor that is exacerbated by feeding or the supine position, laryngomalacia should be strongly considered.

Examination

If the patient is stable after the initial assessment, proceed with the physical examination. A complete head and neck examination can identify micrognathia, posterior tongue displacement, or cysts, and some extrinsic causes of airway compression (eg, masses or lymphatic malformations) that can be the source of stridor.⁷ Signs of infection such as a fever, rhinorrhea, pharyngitis, and tender lymphadenopathy can narrow the differential diagnosis, as these signs make acute infectious causes of stridor most likely.³² The lungs should be auscultated to ensure bilateral breath sounds and chest wall movement, especially if there is concern for foreign body aspiration. If there are asymmetric breath sounds, this would suggest that a foreign body has moved past the carina. The patient should always be approached in a calm manner to reduce agitation that could result in complete airway obstruction.

Vital signs should be obtained, if possible. Fever can indicate an infectious etiology, and tachycardia and tachypnea are often initial signs of respiratory distress. If it will not cause the child significant distress, a pulse oximeter should be used to measure for hypoxemia. Significant hypoxemia can indicate near-complete obstruction and should prompt the clinician to administer therapies with quick onset of action, such as nebulized racemic epinephrine in cases of croup. While nebulized racemic epinephrine is often the treatment of choice for croup, some studies have shown that nebulized nonracemic epinephrine is also equally efficacious and well-tolerated.³³ Rarely, an arterial blood gas test may be useful in determining the degree of hypoxemia and hypercapnia, to guide the need for emergent airway stabilization. Pulsus paradoxus can also be present in croup, and its magnitude has been shown to correlate with croup severity. The severity of croup can be measured by the Westley Croup Score.²⁷

Link to online MDcalc calculator for the Westley Croup Score:

<https://www.mdcalc.com/westley-croup-score>

Diagnostic Studies

In the initial management of stridor, laboratory and radiographic data are often low-yield. Rapid viral antigen testing, heterophile antibody testing, and bacterial cultures may identify specific organisms in cases of infection; however, results from

these tests rarely alter initial management. Most causes of stridor are determined clinically; however, imaging studies can be helpful in establishing a definitive diagnosis in specific instances, or when the diagnosis or response to treatment is unclear or unexpected.²

Radiographic Imaging

X-ray is often the quickest and most readily available imaging modality in the ED. In cases of significant obstruction in an unstable child, an x-ray can be obtained without the child leaving the ED. While croup should be diagnosed clinically and does not require an x-ray for diagnosis, a soft-tissue neck x-ray may be obtained to help assess for other possible diagnoses such as epiglottitis, neck mass, retropharyngeal abscess, or foreign body. The classic x-ray finding in croup is a “steeple” sign caused by narrowing of the subglottic area. However, a negative x-ray does not rule out the diagnosis, as about half of children with a diagnosis of croup have a normal neck x-ray.^{34,35} Similarly, the steeple sign is not pathognomonic of croup and, thus, does not unequivocally prove its presence. Epiglottitis has a classic lateral x-ray finding of an enlarged, thickened epiglottis called the “thumbprint” sign.^{30,36} (See **Figure 2.**) Maintain a high level of suspicion for epiglottitis in a child presenting with drooling, agitation,

Figure 2. Lateral Neck X-ray Demonstrating the Thumbprint Sign of Edema of the Epiglottis



Image courtesy of Melissa Langhan, MD.

and no cough. However, given the relatively low incidence of epiglottitis in cases of stridor, radiographs are often obtained to confirm the diagnosis in a stable child.³⁷ Among children with bacterial tracheitis, a lateral neck x-ray may show nonspecific subglottic narrowing or irregularities of the anterior wall known as the “candle dripping” sign.²⁸

In certain instances, x-ray may diagnose the etiology of stridor, such as in a child with a history of possible foreign body ingestion. (See Figure 3.) If the object is radiopaque, a chest x-ray and/or lateral decubitus films can clarify whether the foreign body is in the trachea or the esophagus, which will help define the plan for possible removal. More-subtle signs of foreign body aspiration include asymmetric hyperinflation and hyperlucency or atelectasis. When the history is unclear, obtaining an x-ray to rule out a foreign body has few risks and many potential benefits, if a diagnosis is made.³⁸ However, if suspicion remains high after a negative radiograph, direct visualization by endoscopy should be pursued.³⁹

X-ray is also used as an initial screening tool. When a positive finding is found on x-ray, further imaging—such as computed tomography (CT) scan or magnetic resonance imaging (MRI)—is often used to clarify those results. For example, a retropharyngeal abscess can be suspected radiographically by the presence of > 5 mm to 7 mm widening of the prevertebral soft tissue at the C2 spinal level

Figure 3. Lateral Neck X-Ray Demonstrating 2 Magnets Around the Epiglottis



Image courtesy of Melissa Langhan, MD.

on lateral x-ray, with the neck in partial extension. Once suspected on x-ray, a CT scan may be necessary to provide further clarification and plan management.⁴⁰

In general, CT scans and MRI are not particularly helpful in diagnosing the most common etiologies of stridor. More importantly, the emergency clinician needs to be careful with imaging that requires a patient with airway compromise to be placed in the supine position or given sedation, as this may precipitate complete airway obstruction and respiratory arrest. CT and MRI scans are used mostly in the evaluation of airway lesions prior to planned surgical intervention. (See Figure 4.)

Figure 4. Neck MRIs Demonstrating a Soft-Tissue Mass Obstructing the Airway at the Base of the Tongue



Images courtesy of Melissa Langhan, MD.

Abbreviation: MRI, magnetic resonance imaging.

Endoscopy

Acute Stridor

Laryngoscopy is a useful tool in evaluating certain children with acute upper airway obstruction in the ED. One benefit of flexible laryngoscopy is that it can be performed at the bedside; however, it is limited in that it will only visualize supraglottic structures. Laryngoscopy can be used in patients with thermal burns to visualize and evaluate the damage to tissues of the upper airway and determine the need for possible intubation. The information obtained from direct visualization can also be used to prognosticate outcomes in these patients.⁴¹ Laryngoscopy is also considered the best method for diagnosing epiglottitis, although it should be performed only if the airway is secure. In patients with bacterial tracheitis, direct visualization is considered the most effective way to confirm the diagnosis and is also helpful in ruling out epiglottitis, which can have a similar presentation.²⁸ Airway fluoroscopy is another means of evaluation; however, its utility as a screening tool is uncertain as the sensitivity is poor, despite high specificity.^{42,43} If the patient has a clear history of aspiration, abnormal physical examination findings or imaging, or persistent symptoms such as cough, drooling, and dyspnea, bronchoscopy is indicated for evaluation of foreign body aspiration below the glottis,⁴⁴ but it comes with greater risk, as it requires anesthesia.

Chronic Stridor

When assessing for etiologies of chronic stridor, endoscopy is often considered the optimal diagnostic study, as it can help determine the primary diagnosis as well as concomitant diagnoses.⁴⁵ Flexible bronchoscopy or laryngoscopy is valuable for rapid anatomic airway evaluation and dynamic airway etiologies that are best seen when a child is not under general anesthesia (eg, laryngomalacia and tracheomalacia).^{46,47} Laryngomalacia is a common cause of chronic stridor in children and is often definitively diagnosed by endoscopy to ensure there is no alternative anatomical etiology for the stridor, as this can be present in up to 18% of cases. Shortened aryepiglottic folds, an omega-shaped epiglottis, or redundant aryepiglottic mucosa may be visualized.⁴⁸ In cases of suspected vocal cord dysfunction, laryngoscopy is often performed to visualize real-time movement of the vocal cords. Children with chronic stridor that has been diagnosed as recurrent croup may benefit from bronchoscopy, as reflux and other treatable conditions are sometimes otherwise missed or misdiagnosed.⁴⁹⁻⁵⁵ Endoscopy is also used in cases where there is concern for a possible fixed lesion such as a papilloma, mass, or hemangioma, as the structure can be visualized and a biopsy obtained if necessary for diagnosis.

Management

Emergent Airway Management

When a child presents in respiratory distress secondary to stridor, the primary role of the emergency clinician is airway management. The team should always be prepared for the worst-case scenario and have all necessary team members present.³² If there is suspicion for a difficult intubation or the need for a surgical airway, otolaryngology (ear, nose, and throat [ENT]) and anesthesiology consultants should be contacted as soon as possible. If these resources are not available, transferring the patient to a tertiary care center should be considered. If a surgical airway is being considered, an operating room should be secured.⁵⁶ Endotracheal tube (ETT) size should be considered carefully, as children with acute-onset stridor may have swelling, requiring a smaller ETT size than expected. Upon arrival, all team members should make an effort to keep the patient and family calm. The child should be allowed to maintain a position of comfort to prevent airway compromise until a more permanent airway can be obtained.

When available and needed, induction with nitric oxide and halogenated gases (eg, halothane, isoflurane, and sevoflurane) is often the best method to relax the patient prior to intravenous line placement or placing the child supine to prepare for intubation.³² Sedative agents that have a higher risk for causing laryngospasm (eg, ketamine) should be avoided unless the emergency clinicians are prepared to intubate. In older, cooperative patients, awake fiberoptic intubation may be an option.^{32,57} In this rare event, awake intubation should be undertaken by experienced clinicians after local airway anesthesia has been provided.

Management of Infectious Etiologies

Croup

Croup is the most common cause of acute stridor in children, manifested by a barking cough, hoarseness, and inspiratory stridor. Most cases of croup are viral, with parainfluenza being the most common virus.⁵⁸ Antibiotics should be initiated only in cases where bacterial superinfection is suspected.⁵⁹ Otherwise, antibiotics are not warranted and management should focus on reducing the inflammation causing the obstruction.

Corticosteroids are the mainstay of treatment for croup of all severity, and they have been shown to decrease hospital admission rates and return visits to the ED, as well as to improve symptoms in patients with mild croup.⁶⁰ The severity of croup has decreased dramatically with increasing liberalization of corticosteroid use for treatment; croup that leads to respiratory failure is rare.^{59,60} Studies have shown that the effects of glucocorticoids are evident at 6 hours and last up to 12 hours.⁶¹ No difference in

the effectiveness between intramuscular and oral administration of corticosteroids in outpatient management of croup has been demonstrated.⁶¹⁻⁶³ No additive benefit of budesonide plus dexamethasone over dexamethasone alone has been established.⁶⁴ The ideal dexamethasone dose is debated. Earlier studies used a dose of 0.6 mg/kg; however, most studies comparing 0.6 mg/kg (max dose, 12 mg) to smaller doses 0.15 mg/kg (max dose, 3 mg) have shown no difference in resulting croup scores between these doses of dexamethasone.^{65,66}

In a 2013 Cochrane review, heliox was shown to have some short-term benefit in children with moderate-to-severe croup when used in conjunction with dexamethasone. However, heliox alone has not been shown to provide a significant change in croup scores.⁶⁷⁻⁶⁹

In children presenting to the ED with moderate-to-severe croup, nebulized epinephrine is often used to induce vasoconstriction as a means of reducing airway swelling. The onset of action of nebulized epinephrine is much quicker than that of glucocorticoids, showing improvement in 30 minutes and lasting approximately 2 hours. There has been no evidence to support the use of racemic epinephrine (0.5 mL of 2.25% solution diluted in 3 mL normal saline) over standard nebulized L-epinephrine (5 mL of 1 mg/mL).⁷⁰ The use of nebulized epinephrine, in addition to dexamethasone, has shown greater benefit than dexamethasone alone when comparing Westley Croup scores.⁷¹ (For the purposes of this article, *nebulized epinephrine* refers to either nebulized racemic epinephrine or nebulized L-epinephrine.)

Humidified air was once thought to improve outcomes in children with croup, but several studies have shown no reduction in admission rates or symptoms with its use.^{72,73} Similarly, there has been no proven benefit to oral decongestants, antibiotics, or beta agonists.⁵⁹

During observation in the ED, patients should have frequent clinical reassessments to evaluate for resolution or progression of symptoms. Children who present with recurrent croup may have other diagnoses that mimic croup, such as subglottic stenosis, gastroesophageal reflux disease, allergies, or sleep-disordered breathing.^{54,74} These children are also more likely to have a history of atopy and wheezing.⁵⁵ Further outpatient evaluation may be warranted to assess for secondary diagnoses.

Epiglottitis

Epiglottitis is a true respiratory emergency, and airway management should be the primary focus. Upon arrival and clinical suspicion for epiglottitis, ENT and anesthesia should be consulted immediately; intubation in the operating room is safest in the event a surgical airway is necessary, such as

emergent tracheostomy or cricothyrotomy. An emergency clinician who has the ability to manage the airway should remain with the patient at all times. Although airway stabilization is the primary consideration in patients with epiglottitis, among the 342 patient admissions in the Kids' Inpatient Database, only 40 children (mostly aged < 2 years) required intubation or tracheotomy.²² While many reviews on the management of epiglottitis do not encourage an examination of the oropharynx, a study by Mauro et al examined the epiglottis of 155 children presenting with stridor, 6 of whom had acute epiglottitis. Examination of the epiglottis enabled providers to distinguish between croup and epiglottitis, and no adverse events were noted.³⁷

Epiglottitis can most reliably be differentiated from croup in that children with epiglottitis often do not have a cough and most often present with drooling and agitation.^{37,75} Although posttraumatic epiglottitis has been reported after foreign body ingestion, the vast majority of cases of epiglottitis are due to infectious causes.⁷⁶ Antibiotic treatment is similar to that of bacterial tracheitis, with a third-generation cephalosporin (eg, ceftriaxone) or a beta-lactamase-resistant penicillin (eg, ampicillin/sulbactam) recommended as empiric therapy. Corticosteroids have not been shown to have any significant benefit in acute epiglottitis, as they do not decrease the length of ICU stay or the duration of intubation.^{19,40}

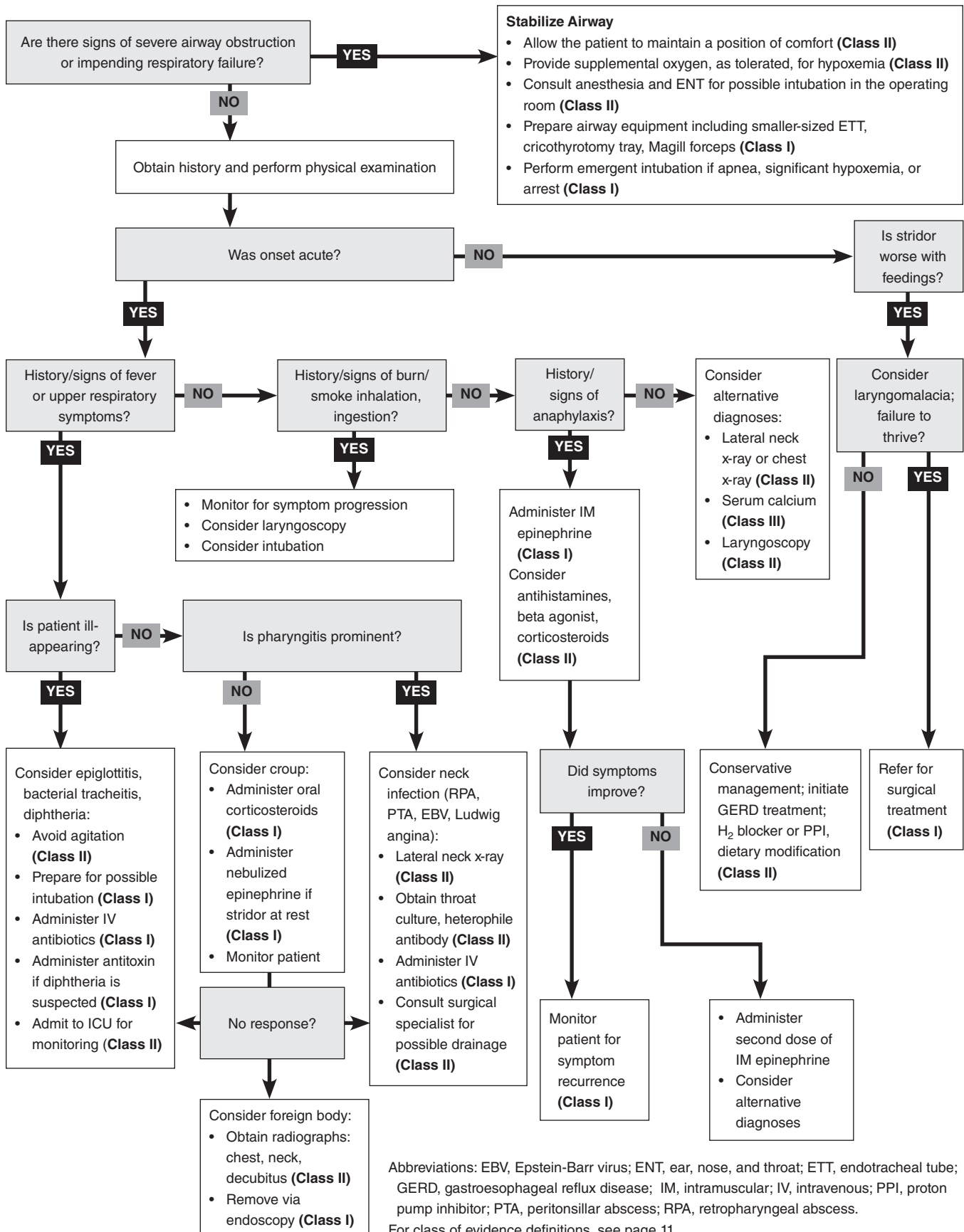
Bacterial Tracheitis

Bacterial tracheitis is a potentially life-threatening etiology of upper airway obstruction caused by subglottic edema and mucopurulent secretions. It can be differentiated from croup in that the patient will often have a high fever and be ill-appearing. Similar to croup, bacterial tracheitis is most often seen in toddlers and early school-aged children and is preceded by symptoms of an upper respiratory infection.²⁸ Whereas most viral respiratory infections improve over time, patients with bacterial tracheitis develop an acute worsening of symptoms. Unlike epiglottitis, however, these children can usually control their secretions and often have a cough.²⁰ Bacterial tracheitis should always be considered in a child who does not respond as expected to the standard care for croup.⁷⁷

Once a clinical diagnosis is made, broad-spectrum antibiotics should be initiated. First-line therapy for bacterial tracheitis is a third-generation cephalosporin (eg, ceftriaxone) or a beta-lactamase-resistant penicillin (eg, ampicillin/sulbactam). If there is concern for methicillin-resistant *S aureus*, vancomycin should be administered concomitantly. A 10- to 14-day course of antibiotics is recommended, initially parenterally, until the child is afebrile for 48 hours and can tolerate oral antibiotics.²⁸

Early and effective airway management (including intubation) may be necessary in children with bacterial tracheitis.⁷⁸ A smaller-size ETT is

Clinical Pathway for Management of Pediatric Patients With Stridor in the Emergency Department



often required secondary to inflammation. Once a child is intubated, aggressive suctioning and pulmonary toilet should be initiated to aid in clearance of airway secretions.

Mononucleosis

Infectious mononucleosis is seen in approximately 7% of patients who present with the complaint of pharyngitis. The presence of posterior cervical lymphadenopathy, splenomegaly, or atypical lymphocytosis increases the likelihood of this diagnosis.¹⁶ Mononucleosis often follows a benign self-limited course in children; however, upper airway obstruction can be an acute and severe complication. Airway obstruction most commonly results from lymphoid hyperplasia of the Waldeyer ring.⁷⁹ Because Epstein-Barr virus is responsible for the majority of cases of infectious mononucleosis, antibiotics are not routinely warranted, even in the cases of severe airway obstruction. Systemic corticosteroids have been shown to be useful in reducing inflammation and should be initiated if significant airway obstruction is present.⁸⁰⁻⁸² Supportive measures, such as elevation of the head of the bed and humidified air, can also aid in resolving obstructive symptoms.⁸³

Diphtheria

Caused by *Corynebacterium diphtheriae*, diphtheria typically starts as a croup-like illness, but can progress to sepsis or suffocation from pseudomembranes if not properly treated. Immunization programs have made this disease rare in many countries; diphtheria is seen more commonly among immigrants and nonvaccinated individuals. In the United States, treatment of diphtheria can be accomplished with high-dose penicillin (or erythromycin for patients who are allergic to penicillin) as well as diphtheria antitoxin. Emergent airway management or tracheotomy may be required for patients in whom pseudomembranes cause obstruction.¹⁹ For more information regarding the diagnosis and management of diphtheria, see the February 2017 issue of *Pediatric*

Emergency Medicine Practice titled “Diphtheria, Pertussis, and Tetanus: Evidence-Based Management of Pediatric Patients in the Emergency Department,” available at: www.ebmedicine.net/DPT.

Deep Space Neck Infections

Retropharyngeal abscesses, peritonsillar abscesses, and Ludwig angina are other types of bacterial infections of the oropharynx and neck. Stridor due to compression of the airway would be a late, and rare, sign in these patients. Airway stabilization and parenteral antibiotics are the initial steps in treatment, followed by surgical consultation for possible drainage or decompression.⁸⁴ Antibiotics (eg, ampicillin/sulbactam) should cover aerobic and anaerobic bacteria including *Streptococcus*, *Staphylococcus*, and gram-negative rods.

Management of Noninfectious Etiologies

Foreign Bodies

Foreign body aspiration is associated with significant morbidity and mortality in young children, especially when there is no supportive history, as this often results in a delay in the diagnosis. Foreign body aspiration is a common cause of mortality in children aged < 2 years and is often unwitnessed.¹² Management of foreign body aspiration is timely removal, either with Magill forceps (if the foreign body can be visualized above the vocal cords) or via rigid bronchoscopy (for deeper foreign bodies).³⁸ If there is sudden dislodgement of the foreign body, an acute hypoxic event may occur, requiring emergent need to secure the airway.^{85,86} Immediate airway protective maneuvers include the Heimlich maneuver, jaw thrust, and nasal or oral airways.³⁸ Cricothyroidotomy (needle or routine) or tracheostomy may be indicated if the foreign body is subglottic,⁸⁷ depending on the availability of resources and the skill set of the emergency clinician.⁸⁸ For further information regarding the management of inhaled foreign bodies in pediatric patients, see the October 2015 issue of *Pediatric Emergency Medicine*

Class of Evidence Definitions

Each action in the clinical pathways section of *Pediatric Emergency Medicine Practice* receives a score based on the following definitions.

Class I

- Always acceptable, safe
- Definitely useful
- Proven in both efficacy and effectiveness

Level of Evidence:

- One or more large prospective studies are present (with rare exceptions)
- High-quality meta-analyses
- Study results consistently positive and compelling

Class II

- Safe, acceptable
- Probably useful

Level of Evidence:

- Generally higher levels of evidence
- Nonrandomized or retrospective studies: historic, cohort, or case control studies
- Less robust randomized controlled trials
- Results consistently positive

Class III

- May be acceptable
- Possibly useful
- Considered optional or alternative treatments

Level of Evidence:

- Generally lower or intermediate levels of evidence
- Case series, animal studies, consensus panels
- Occasionally positive results

Indeterminate

- Continuing area of research
- No recommendations until further research

Level of Evidence:

- Evidence not available
- Higher studies in progress
- Results inconsistent, contradictory
- Results not compelling

This clinical pathway is intended to supplement, rather than substitute for, professional judgment and may be changed depending upon a patient's individual needs. Failure to comply with this pathway does not represent a breach of the standard of care.

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Practice titled, "Inhaled Foreign Bodies in Pediatric Patients: Proven Management Techniques in the Emergency Department," available at: www.ebmedicine.net/foreignbodies.

Anaphylaxis

Although potentially underdiagnosed, anaphylaxis is a clinical presentation that most emergency clinicians are comfortable managing, especially in pediatric patients. Stridor has been reported in up to 18% of children presenting with food-induced anaphylaxis.⁸⁹ Intramuscular epinephrine is the first-line therapy in acute anaphylaxis, as it is the only medication that has been proven to be life-saving. The recommended dose of epinephrine is 0.01 mg/kg of 1 mg/mL solution to a maximum dose of 0.3 mg. If using an epinephrine autoinjector, a 0.15 mg dose should be used for children weighing \leq 25 kg, and a 0.3 mg dose used for children weighing $>$ 25 kg. For children weighing $<$ 15 kg, some studies have shown the potential for intraosseous injection with autoinjectors, given the standard 12.7-mm needle length. There is also known overdosage of epinephrine in children weighing $<$ 15 kg who are given the standard 0.15 mg dose in autoinjectors.⁹⁰ However, in emergency situations, autoinjectors reduce dosing errors and should be used if they are readily available. Blood pressure should be monitored and fluid resuscitation given as needed. If there is minimal or waning response to intramuscular epinephrine, a second intramuscular dose or continuous intravenous epinephrine infusion may need to be administered.

There is little evidence to support the use of antihistamines in the acute treatment of anaphylaxis. H₁ blockers are most useful for symptomatic treatment of urticaria, pruritus, and nasal/ocular symptoms. H₂ blockers can be used for gastrointestinal manifestations of anaphylaxis. Bronchodilators aid the management of lower airway symptoms, such as wheezing. Corticosteroids have a slow onset of action (4-5 hours), and, therefore, are not necessarily useful in acute management of anaphylaxis, but are sometimes administered for the prevention of a biphasic reaction.^{91,92}

Airway Ingestions and Burns

Chemical ingestions and inhalations can result in upper airway compromise secondary to mucosal injury and edema. Detergent powders and corrosives may lead to acute stridor and respiratory distress.⁹³ Supportive care is the mainstay of treatment for these children, starting with the administration of 100% oxygen. The use of corticosteroids is controversial in these patients. While corticosteroids are useful in modifying the inflammatory response and reducing upper airway edema, corticosteroids have not been shown to have significant benefit in reducing the incidence of stricture formation.⁹⁴ Antireflux

medications are often initiated after an ingestion to prevent secondary injury. The challenge for emergency clinicians is determining which children will progress to have severe respiratory distress and require further airway stabilization.⁹⁵ In thermal inhalations, patients with laryngeal edema are much more likely to require intubation than those without. While many emergency clinicians would consider intubating the patient with an inhalational burn who presents with stridor, hoarseness, or drooling, a small study did not find those factors entirely predictive of need for intubation.⁹⁵ If there is concern for laryngeal edema on clinical presentation, fiberoptic laryngoscopy may be performed to help make an informed decision regarding the need for intubation if time allows and appropriate resources are present. If edema is present, intubation should be pursued urgently, as inflammation can progress rapidly and result in complete occlusion of the airway.^{41,93,95} Cuffed ETTs are preferred over uncuffed ETTs and cause fewer adverse events.⁹⁶

Vocal Cord Disorders

Vocal cord paralysis is a common laryngeal abnormality in children that can be unilateral or bilateral and either congenital or acquired. Bilateral vocal cord paralysis can be associated with neurological conditions such as hydrocephalus and Arnold-Chiari malformations, as well as traumatic conditions such as surgery, intubation, and birth trauma from forceps.⁹⁷ Other rare causes include myasthenia gravis, metabolic causes, and peripheral neuropathy.⁹⁸ Cardiac surgery that causes recurrent laryngeal nerve injury is the most common cause of unilateral vocal cord paralysis.⁹⁹ Children with bilateral vocal cord paralysis are more likely to have stridor, whereas those with unilateral paralysis are more likely to have a change in voice.⁹⁷

The majority of children with bilateral vocal cord paralysis present prior to 2 years of age.⁹⁸ For those children who present to the ED acutely, there are several maneuvers that can help open the airway in patients with vocal cord paralysis, including breathing through a straw, pursed-lip breathing, and panting with frequent, shallow breaths. Heliox can also be trialed, as it can reduce airway resistance and may improve symptoms in a child with vocal cord paralysis, although the evidence for this is not robust.¹⁰⁰ Fiberoptic laryngoscopy is often needed to make this diagnosis; however, ultrasound has recently been shown to have good sensitivity as well.¹⁰¹ Approximately 50% of children with bilateral paralysis will require tracheostomy to secure their airway. Those not requiring tracheostomy should be followed serially for return of laryngeal function, which usually occurs from 6 weeks to 5 years after diagnosis.^{98,102} In unilateral paralysis, speech therapy can be helpful in strengthening compensa-

tory mechanisms for glottis closure, which can help phonation and improve feeding.¹⁰³

Vocal cord dysfunction is an intermittent adduction of the vocal cords during inspiration and can present with stridor. It is most commonly misdiagnosed as asthma and should be considered in a patient deemed to have uncontrolled asthma.¹⁰⁰ Exercise-induced vocal cord dysfunction has been described among athletic females and may be confused with exercise-induced asthma.¹⁰⁴

Management of Chronic Etiologies

Laryngomalacia

Laryngomalacia is the most common congenital laryngeal anomaly and the most common etiology of neonatal stridor. Stridor presents most often at 2 weeks of age and resolves by 18 months. Often, stridor is worse with feeding and improves when the infant is placed in the prone position.²⁹ Laryngomalacia is also associated with feeding difficulties, which can improve with modifications such as pacing, thickening feeds, and upright positioning while feeding.⁴⁸ There is also a well-established association between laryngomalacia and gastroesophageal reflux disorder; treatment of gastroesophageal reflux disorder in children with laryngomalacia has been shown to improve and shorten symptom course, with a better clinical outcome.²⁹ Severe cases may present with respiratory distress (eg, retractions and difficulty breathing), obstructive sleep apnea, and failure to thrive, and it is often associated with tracheomalacia or subglottic stenosis.⁵⁰ Laryngomalacia can also present in older children, and may be exercise-induced.¹⁰⁴ Most cases self-resolve with watchful waiting and conservative medical management, but more severe cases may require surgical intervention with supraglottoplasty.^{105,106}

Tracheomalacia

Unlike laryngomalacia, tracheomalacia presents with expiratory stridor instead of inspiratory stridor. However, children also may present with apnea or recurrent pneumonia, which are indications for emergent surgical repair. While there is no consensus on medical treatment for tracheomalacia, some options include the use of nebulized hypertonic saline and inhaled corticosteroids to reduce airway secretions.⁴⁶ Most infants with tracheomalacia have improvement in symptoms, without any treatment, by 2 years of age.

Subglottic and Tracheal Stenosis

Subglottic and tracheal stenosis can be congenital, or it can be acquired after a period of tracheal intubation. Subglottic stenosis is classified based on the Myer-Cotton classification system, with grade I indicating 1% to 50% stenosis, grade II indicating 51% to 70% stenosis, and grade III indicating 71% to

99% stenosis.¹⁰² If known, the grade may help guide correct ETT sizing, if needed. Grade I and grade II stenosis are usually managed conservatively, if there is no associated morbidity. In cases of severe respiratory distress due to concomitant inflammation, heliox may avert the need for intubation.⁶⁸ Early endoscopic balloon dilation is one approach to treatment, and open surgery (including cricoid split, laryngotracheal reconstruction, or cricotracheal resection) is another.^{102,107-109} Most cases of congenital stenosis will resolve on their own, but severe cases may require tracheostomy.¹⁰⁵

Rings, Slings, and Other Etiologies

Obstructive anomalies that result in extrinsic compression of the airway will often result in biphasic stridor. These can include vascular rings or slings, laryngeal and tracheal webs, cysts, hemangiomas, and neoplasms.^{105,110-112} Diagnostic imaging or laryngoscopy can aid in determining the extent of the compressive lesion, which will help guide management.¹⁰⁵ In cases where a mass is found on imaging, referral should be made to the surgical team for potential biopsy.¹¹³ Angiography can also be useful with concern for vascular malformations, and bronchoscopy is especially helpful to further investigate tracheal pathology.^{45,47,114,115} Surgical management is often needed to repair, dilate, or excise these lesions.^{47,116} Subglottic cysts may recur after surgery.⁵¹ Laser resection is often used in cases of papillomas, but lesions may recur.¹¹⁷ Propranolol has been used in the treatment of subglottic hemangiomas with similar effectiveness as surgery.^{112,118,119}

Special Circumstances

Immunization status should be carefully considered in cases of acute infectious stridor. While *Streptococcus* and *Staphylococcus* are now at the forefront of many bacterial infectious etiologies of upper airway obstruction, *H influenzae* and diphtheria should be carefully considered in unimmunized children.

Children with hypotonia, such as those with trisomy 21 (Down syndrome), are especially prone to upper airway obstruction. Of children with trisomy 21, 79% have either current symptomatic upper airway obstruction or a history of an adenotonsillectomy. Children with hypotonia commonly have tracheobronchomalacia and/or subglottic/tracheal stenosis, which is 10 times more common in children with trisomy 21. When a child with hypotonia presents with stridor, suspect a higher likelihood of underlying pathology and remain vigilant in the evaluation.¹²⁰

Craniofacial abnormalities in children may make intubation difficult, especially in emergency situations, and should be carefully considered and planned for upon presentation. Genetic syndromes associated with

micrognathia and glossoptosis make intubation technically challenging. Patients with craniofacial abnormalities are particularly prone to upper airway obstruction, so a broad differential of chronic and congenital etiologies should be carefully considered.²⁷

Controversies and Cutting Edge

Controversy and differences in clinical practice exist when it comes to the management of croup. The optimal dose of dexamethasone has yet to be defined. Wide interhospital variability in admission rates and administration of glucocorticoids for croup remain.⁶¹ More research is needed to determine which children will need inpatient admission for further nebulized or systemic epinephrine after initial treatment in the ED.

With the development of the Hib vaccine, there has been a recent shift in the epidemiology of bacterial upper airway obstruction, especially epiglottitis. As more vaccinations are being created, the organisms causing disease may continue to evolve.

Airway fluoroscopy is currently being evaluated to establish diagnoses in patients presenting with stridor. Fluoroscopy may serve as an adjunct to flexible fiberoptic laryngoscopy, given that the latter can visualize only the supraglottic area. Sensitivity for diagnosing conditions is varied and further prospective evaluation is warranted.⁴²

Disposition

The etiology of the stridor and a child's response to treatment are the most important determining factors when deciding which children are safe for discharge home from the ED. All children with stridor should be observed following treatment to ensure sustained improvement of symptoms, as there is potential for rapid deterioration after the effects of initial treatment have worn off.

The most common presentation of stridor to the ED is croup, and the majority of children with croup are considered safe for discharge home after appropriate observation if they have sustained resolution of stridor after treatment (with no stridor at rest), no signs of increased work of breathing, no hypoxemia, no need for supplemental oxygen, and the ability to handle secretions and tolerate oral intake. However, most other etiologies of acute stridor, such as tracheitis, epiglottitis, and foreign body aspiration, need a more prolonged course of treatment and closer observation, requiring admission to the hospital.

Children with croup who have received nebulized epinephrine should be observed in the ED for 2 to 4 hours following treatment to ensure improvement and resolution of stridor at rest. If 2 or more nebulized epinephrine treatments are required, admission to the hospital for further observation and

monitoring for return of symptoms should be considered. Despite admission for observation in these cases, the majority of children with croup do not require further nebulized epinephrine treatments while inpatient.^{121,122}

In cases of stridor secondary to anaphylaxis requiring intramuscular epinephrine administration, children should be routinely monitored in the ED for resolution and monitoring for a potential biphasic reaction after initial resolution of symptoms. Biphasic reactions can occur up to 72 hours after the initial reaction, but all children do not need to be monitored for this duration. The standard observation period is 4 to 6 hours, given that 75% of biphasic reactions will occur within the first 6 hours after intramuscular epinephrine administration. Some authors believe that children with more severe initial anaphylactic reactions (wide pulse pressure, > 1 dose of epinephrine required) and delayed presentation to ED (> 90 minutes from the initial reaction) are more likely to have a subsequent biphasic reaction.¹²³⁻¹²⁶

Children presenting with severe respiratory distress with ongoing concern for the ability to maintain their airway should be admitted for closer monitoring. In cases where a child with acute onset of stridor and respiratory distress does not respond to initial treatment as expected, additional workup should be pursued in the hospital setting. Children with recurrent stridor or recurrent croup also warrant further investigation and workup. For children who are toxic-appearing or experiencing worsening distress, this workup should be continued as an inpatient. However, chronic stridor often requires a multidisciplinary approach and can be pursued as an outpatient unless there is an acute concern for airway stability.¹²⁷

Summary

When evaluating a patient with stridor in the ED, the history and physical examination should guide initial management, as the etiology of stridor can often be a clinical diagnosis without the need for diagnostic testing. The majority of presentations of acute stridor to the ED are of infectious etiology, with croup being the most common. However, a broad differential should always be considered, especially if a patient does not respond as expected to initial management. In cases of stridor, the goals of the emergency clinician are to consider and evaluate for life-threatening causes of stridor as indicated, be prepared for emergent airway stabilization if necessary, and ensure a safe disposition for all patients.

Risk Management Pitfalls for Management of Children With Stridor

- 1. "We must start an IV and get labs now!"**

Children with stridor should be left in positions of comfort, with as little manipulation as possible. Agitating the patient with supplemental oxygen, unnecessary intravenous access, and blood work can lead to worsening respiratory distress; these interventions should be reserved for patients who require parenteral therapy or are deteriorating after history and physical examination.
- 2. "I didn't want to waste time observing a patient with stridor."**

Observation is important in guiding initial management and can provide a significant amount of information almost immediately. Watching for increased work of breathing and drooling after placing the patient in a position of comfort can determine necessary initial interventions.
- 3. "This must be croup. The patient is a 26-month old with stridor."**

All stridor is not croup. When a patient is not responding to initial management, consider other less common etiologies.
- 4. "The child looks comfortable now, so he must be out of the woods."**

Do not underestimate the potential for rapid deterioration in children with stridor. In cases of acute stridor, the airway can be quickly obstructed, so it is important to remain vigilant in monitoring these patients after treatment is initiated.
- 5. "The chances we will need an emergent airway are pretty small, so let's just watch and wait."**

Failure to plan ahead and prepare for an advanced airway can result in morbidity and mortality. If there is the possibility that an emergent airway will be needed, ensure the necessary equipment is available and essential personnel are notified.
- 6. "The child responded to corticosteroids almost immediately, so he is safe for discharge now."**

Steroids do not work immediately. Remain vigilant and take advantage of the observation period. A child can deteriorate after the initial response and may need further interventions.
- 7. "We should give antibiotics just in case this isn't viral croup."**

Most well-appearing children with acute stridor will have croup, which is most likely viral and should not be treated with antibiotics. Antibiotics are warranted in cases of epiglottitis, bacterial tracheitis, peritonsillar abscess, and retropharyngeal abscess.
- 8. "The child needs a CT scan, so he must go off the floor."**

Be judicious in determining which patients are stable enough to leave the ED for diagnostic testing. Consider how the testing will change management acutely.
- 9. "The patient is up-to-date on all vaccines, so this can't be epiglottitis."**

The epidemiology of epiglottitis is changing and is often seen in fully immunized patients. Do not rule out the diagnosis on the basis of vaccine status.
- 10. "We should probably get an x-ray to confirm that this is croup."**

Many cases of stridor are diagnosed clinically and do not require diagnostic testing for confirmation. Additionally, radiographic findings for croup lack sensitivity and specificity.

Time- and Cost-Effective Strategies

- Most causes of stridor can be identified and treated without the need for laboratory testing or imaging. Reserve testing for when the diagnosis is unclear.
- Oral corticosteroids are the mainstay of treatment for croup and have been shown to decrease hospital admission rates and return visits to the ED.⁶⁰
- Children with recurrent episodes of stridor and multiple presentations to the ED warrant outpatient workup for chronic stridor.

Case Conclusions

You determined that the 20-month-old had moderate croup and ordered 1 nebulized epinephrine treatment, which quickly resolved the retractions and stridor at rest. The boy was also given 0.15 mg/kg of oral dexamethasone. No chest x-ray was obtained. The staff allowed the boy to be held by his mother, and he rested peacefully on her lap. After 2 hours, the patient had no further stridor at rest and was breathing comfortably, so he was safely discharged home.

Upon the 4-year-old boy's arrival to the ED, ENT and anesthesia were immediately called, as you had concern for epiglottitis and possible need for emergent airway stabilization. An operating room was secured for possible intubation or surgical airway. The child and his parents were reassured frequently, with as few interventions as possible. The boy was kept in positions of comfort, without supplemental oxygen or additional attempts made to obtain IV access. He continued to drool and maintain a fixed posture. He was taken to the operating room and intubated successfully, and direct laryngoscopy confirmed the diagnosis of epiglottitis. The boy was started on IV ceftriaxone and admitted to the ICU for further management.

After talking more with the parents of the 3-month-old girl, you found out that she had been having intermittent stridor since she was 2 weeks old. When you asked about how feeding was going, her parents said she had always had some feeding difficulties, and they questioned whether she had reflux. Given that she was very well-appearing with normal vital signs and no increased work of breathing, you determined that she most likely had stable chronic stridor. Laryngomalacia was most likely, given the age of onset and the association with feeding difficulty. No diagnostic testing or laboratory work was obtained in the ED. The girl was discharged home with outpatient follow-up for endoscopy to confirm the diagnosis.

Key Points

- Croup is a clinical diagnosis that should be based on history and physical examination findings without the need for diagnostic imaging.
- Avoid agitating children with acute stridor; allow them to maintain positions of comfort to prevent acute airway collapse.
- Plan ahead if an emergent airway may be necessary and be aware of available resources.
- Not all stridor is croup. Maintain a broad differential, especially if a child does not respond to initial management as expected.
- Children presenting with recurrent and chronic stridor warrant a multidisciplinary approach to determine etiology.

References

Evidence-based medicine requires a critical appraisal of the literature based upon study methodology and number of subjects. Not all references are equally robust. The findings of a large, prospective, randomized, and blinded trial should carry more weight than a case report.

To help the reader judge the strength of each reference, pertinent information about the study, such as the type of study and the number of patients in the study is included in bold type following the references, where available. The most informative references cited in this paper, as determined by the author, are noted by an asterisk (*) next to the number of the reference.

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CME Questions



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1. A 6-year-old boy presents to the ED with expiratory stridor. Which of the following anatomic areas is most likely involved in this patient's disease process?
 - a. Supraglottic area
 - b. Glottic area
 - c. Trachea
 - d. Oropharynx
2. Which of the following is the most common cause of acute stridor in children aged < 3 years of age?
 - a. Epiglottitis
 - b. Laryngomalacia
 - c. Anaphylaxis
 - d. Viral croup
3. A 2-year-old child presents to the ED with 2 days of upper respiratory symptoms and new-onset stridor that is worse at night. He is nontoxic-appearing with inspiratory stridor at rest and mild increased work of breathing. To make the diagnosis of croup one should:
 - a. Obtain a chest x-ray
 - b. Order a nasopharyngeal swab for respiratory pathogens
 - c. Perform bedside laryngoscopy
 - d. No diagnostic testing is necessary
4. Which of the following x-ray signs would make you most concerned for an acute life-threatening upper airway obstruction?
 - a. Candle dripping sign on a lateral neck x-ray
 - b. Steeple sign on an anteroposterior view of the neck
 - c. Thumbprint sign on lateral neck x-ray
 - d. Hyperinflation of the right lung on decubitus chest x-ray
5. A child presents to the ED with acute-onset stridor and respiratory distress. The absence of which symptom will make you much more concerned for epiglottitis?
 - a. Cough
 - b. Drooling
 - c. Fever
 - d. Increased work of breathing
6. Which of the following interventions is not recommended in the acute management of epiglottitis?
 - a. Parental comfort
 - b. Parenteral antibiotics
 - c. Anesthesiology consultation
 - d. Steroids
7. A 6-month-old infant presents with stridor that has been present for the last month. Laryngoscopy demonstrates unilateral vocal cord paralysis. Which of the following is most likely to be present in her past medical history?
 - a. Cardiac surgery
 - b. Arnold-Chiari malformation
 - c. Myasthenia gravis
 - d. Hypocalcemia
8. Laryngomalacia is most often associated with which of the following medical diagnoses?
 - a. Asthma
 - b. Gastroesophageal reflux disease
 - c. Milk protein allergy
 - d. Gastrointestinal motility disorder
9. A young girl with trisomy 21 presents with chronic stridor that has been progressively worsening over the past few weeks. Which etiology of chronic stridor is more likely to occur in children with trisomy 21?
 - a. Laryngomalacia
 - b. Subglottic stenosis
 - c. Papillomatosis
 - d. Hemangioma
10. A 10-year-old boy presents with anaphylaxis after ingesting a peanut. He is more likely to have a biphasic reaction if:
 - a. He receives > 1 dose of epinephrine.
 - b. He presents with a narrow pulse pressure.
 - c. He has no recurrent symptoms after 6 hours of observation.
 - d. He presents 30 minutes after ingestion.



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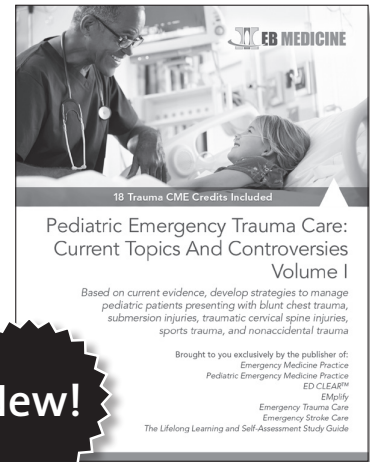
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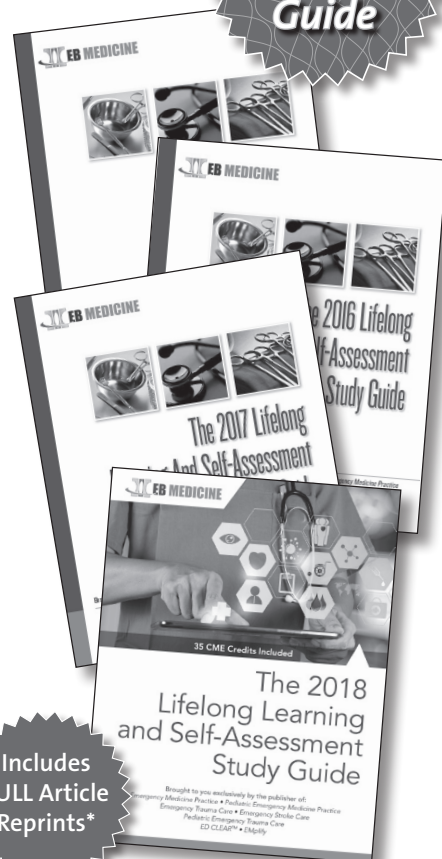
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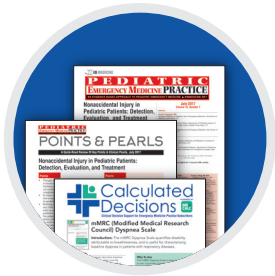
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Needs Assessment: The need for this educational activity was determined by a survey of medical staff, including the editorial board of this publication; review of morbidity and mortality data from the CDC, AHA, NCHS, and ACEP; and evaluation of prior activities for emergency physicians.

Target Audience: This enduring material is designed for emergency medicine physicians, physician assistants, nurse practitioners, and residents.

Goals: Upon completion of this activity, you should be able to: (1) demonstrate medical decision-making based on the strongest clinical evidence; (2) cost-effectively diagnose and treat the most critical ED presentations; and (3) describe the most common medicolegal pitfalls for each topic covered.

CME Objectives: Upon completion of this article you should be able to: (1) identify the most common and serious etiologies that cause acute and chronic stridor; (2) determine necessary diagnostic testing and appropriate use of resources for children with stridor; and (3) manage acute and chronic presentations of stridor in the emergency department.

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