Children's National

Infant Stridor: A 2022 Overview

Habib Zalzal, MD
Assistant Professor
Pediatric Otolaryngologist
Department of Otolaryngology | Children's National Hospital | Washington, D.C.

Objectives

By the end, the learners should be able to

- Understand the pathophysiology of stridor in the neonatal population
- Become comfortable with the work up of a stridulous neonate
- Determine when an otolaryngology evaluation is warranted particularly if otolaryngology is not readily available in your clinical setting
- Understand the role for medical management in stridor
- Understand what conditions requires surgical intervention, when that intervention should occur and what the intervention may look like

Disclosures

I have no financial or commercial interests to disclose.

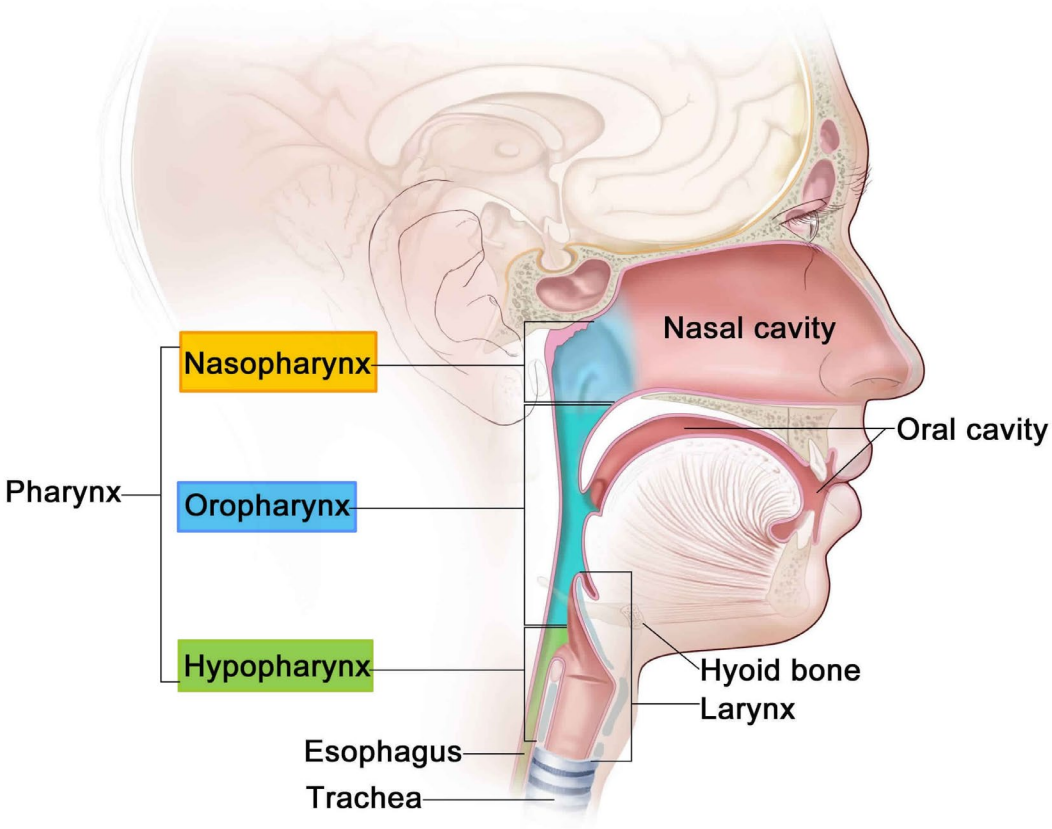
Children's National

Introduction

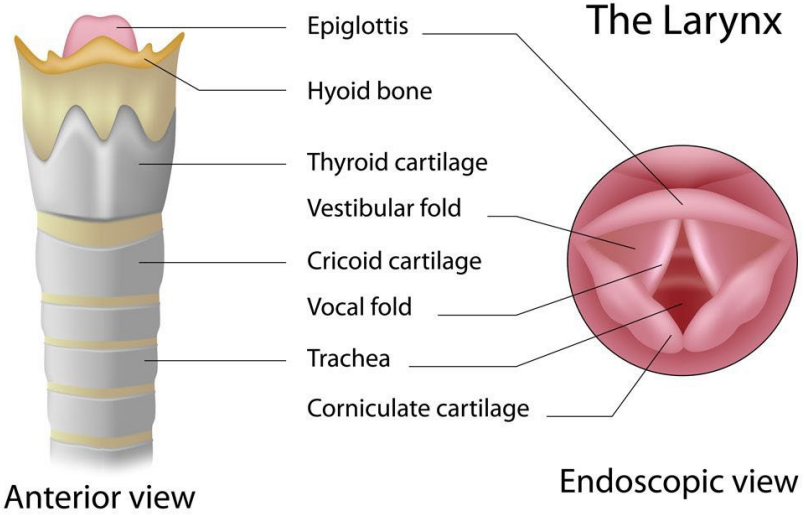
- Stridor is a harsh respiratory noise caused by turbulent airflow through a restricted passage.
- At baseline, stridor is a pathologic clinical sign that should prompt a thorough investigation by the physician.
- Stridor is not a diagnosis, but a sign of a condition that can range from benign, self-limited disorders to rapidly progressing airway obstruction

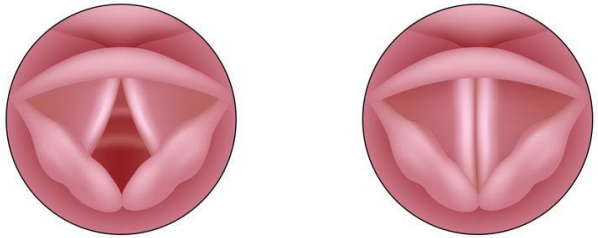
Anatomy

Anatomy of the Pharynx



The Larynx





Respiration *Phonation*

Children's National

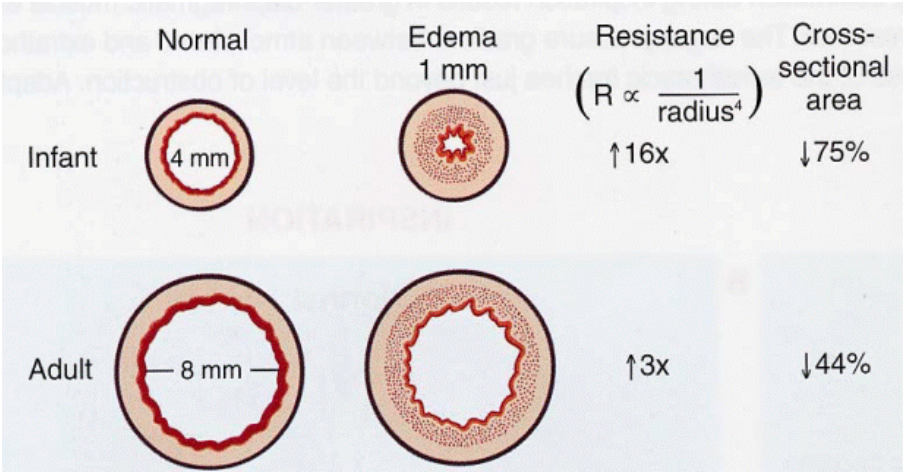
Pathophysiology

What Makes this Noise?

- We need to return to high school physics to recall the properties of flow through a closed system:

1. Poiseuille's Law

– Rate of laminar flow of fluid through a tube

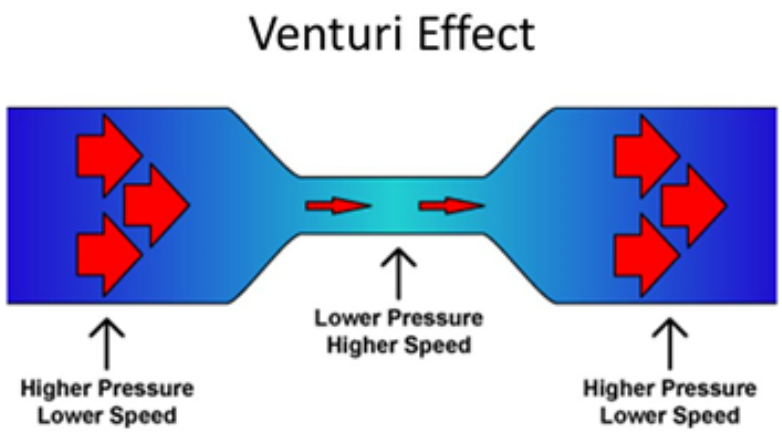


- Small decreases in radius (croup, subglottic stenosis) lead to big increases in resistance, which produces a decrease in flow

What Makes this Noise?

- We need to return to high school physics to recall the properties of flow through a closed system:

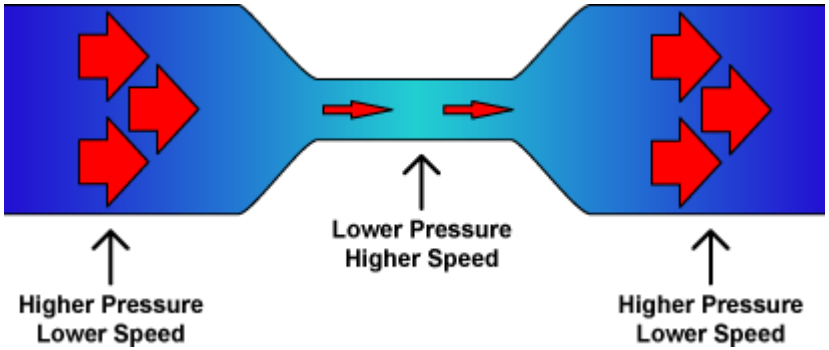
1. Poiseuille's Law
2. **Venturi Effect**
   - With the notable decrease in flow caused by Poiseuille's law, there is an *increase* in the flow velocity



What Makes this Noise?

- We need to return to high school physics to recall the properties of flow through a closed system:

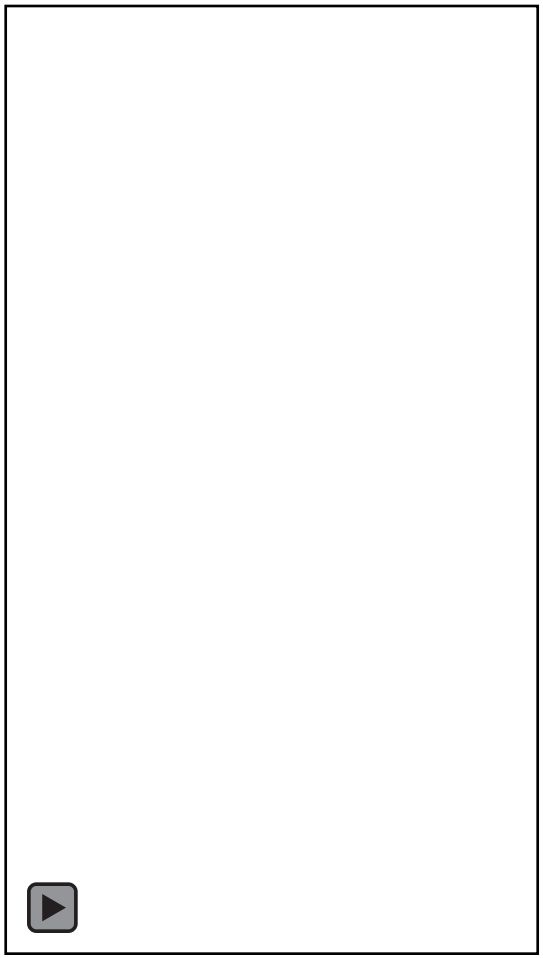
1. Poiseuille's Law
2. Venturi Effect
3. **Bernoulli's Principle**
   - In a closed system as the velocity of a fluid is increased, outward pressure in the system is decreased
     - Smaller Diameter → Faster Flow → Decreased outward Pressure → Inward Collapse → Resonance (Noise)

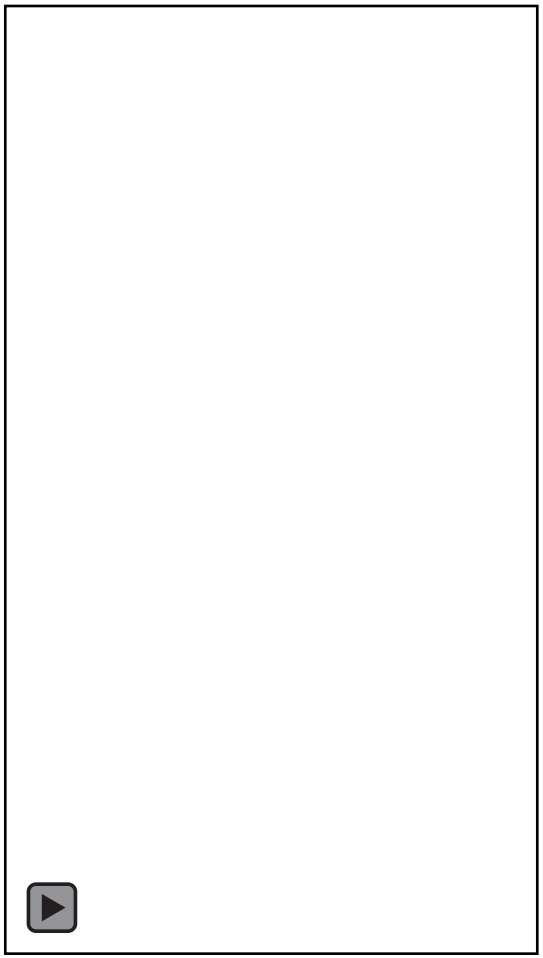


Respiratory Noises

- **Stertor:** a low-pitched, 'snoring-like' respiratory noise during inspiration, typically originating from the nasopharynx
- **Inspiratory Stridor:** high-pitched respiratory noise caused by turbulent airflow during inspiration (larynx or upper trachea)
- **Expiratory Stridor:** a harsh respiratory noise caused by turbulent airflow during expiration (lower trachea or bronchi)
- **Biphasic Stridor:** a harsh respiratory noise throughout the entire respiratory cycle (mid-trachea, glottis, and subglottis)
- **Wheezing:** a whistling respiratory noise with expiration, heard within the lungs secondary to restricted airflow bronchioles

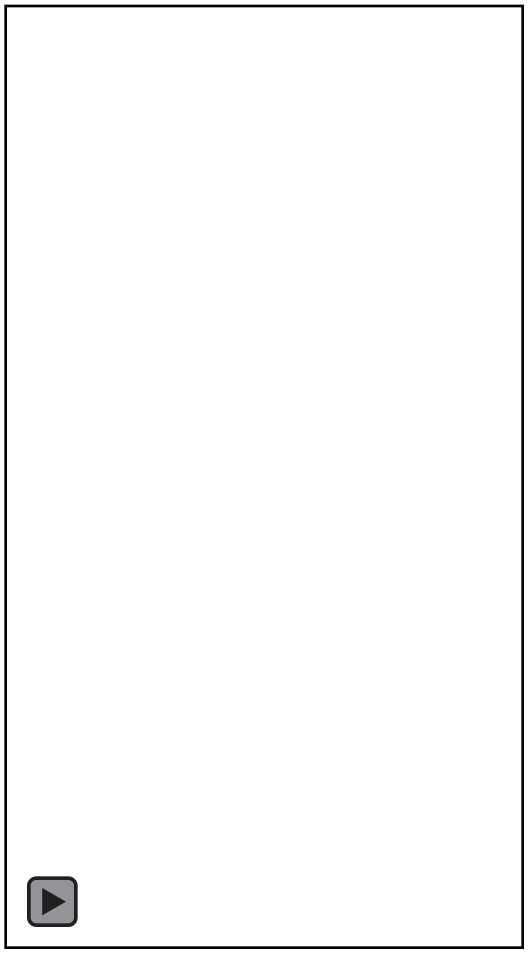
Inspiratory Stridor





(Allen 2022)

Biphasic Stridor



(Allen 2022)

History, Physical Exam, and Overall Work-Up

History & Physical

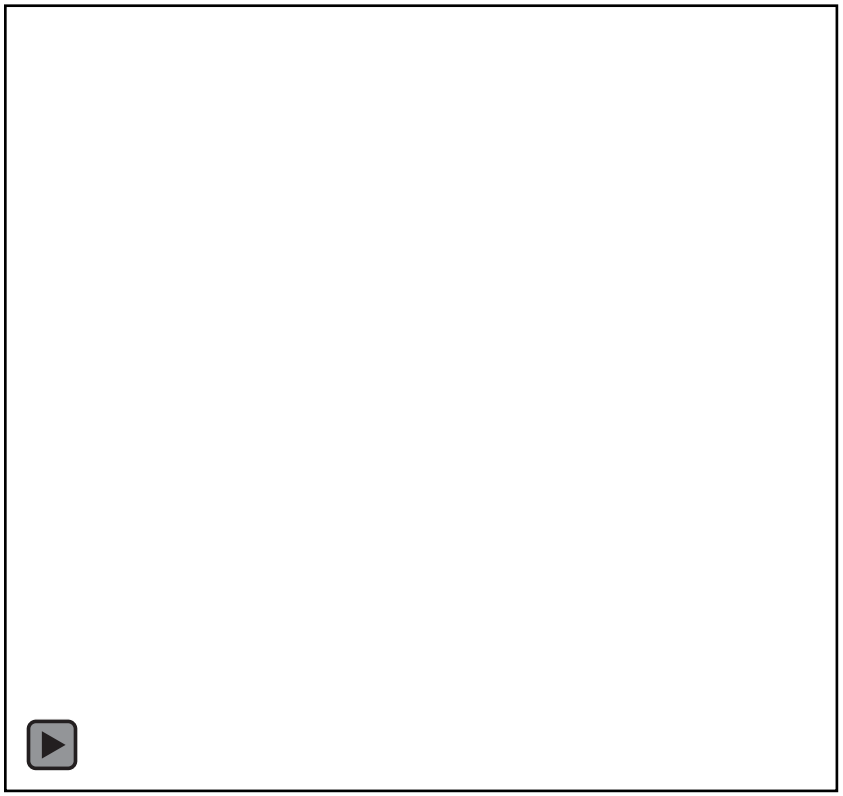
- History is of the upmost importance in diagnosis
  - Duration
  - Onset
  - Quality of the noise
  - Timing/Triggers
  - PMH: Prenatal, Obstetric, NICU, Intubation, and Vaccination history
  - Associated symptoms (fever, cough, weight loss, apnea, brief resolved unexplained event/BRUE)

Physical Exam

- Physical Exam
  - Complete HEENT Exam
    - Listen for the stridor
      - Quality
      - Timing
      - Positioning
      - Severity
  - Examine for respiratory distress
    - Nasal flaring
    - Tracheal tugging
    - Accessory muscle use and asymmetric chest motion
    - Chest retractions (intercostal, sternal, suprasternal, supraclavicular, and subxiphoid)

Ancillary Assessments

- Flexible laryngoscopy
  - Gold standard
- Barium swallow
  - Mostly if there is aspiration risk or cleft suspicion
- Plain film imaging
  - Helpful for subglottic narrowing
- Direct Laryngoscopy (OR)

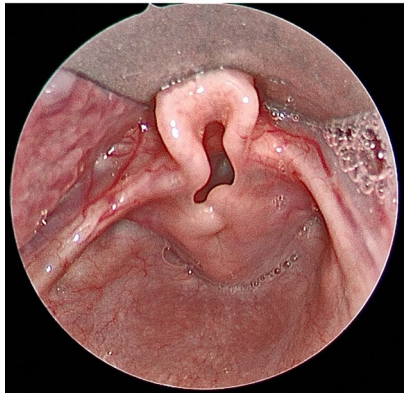


Ancillary Studies

Table 1
Ancillary tests during the workup of specific causes of stridor

	Neck Airway Films	Airway Fluoroscopy	Barium Swallow	Flexible Endoscopy	Direct Laryngoscopy with Bronchoscopy
Laryngomalacia	–	–	–	++	++
Tracheomalacia	–	+	–	–	++
Subglottic stenosis	+	+	–	–	++
Vascular ring	–	–	++	–	++
Laryngeal web	–	–	–	++	++
Laryngeal cleft	–	–	+	+	++
Subglottic hemangioma	+	+	–	–	++

(Zalzal & Zalzal 2022)



Stridulous Patient

History and Physical

Acute or Severe Symptomology

Mild, Recurrent, or Chronic Symptomology

If stable, flexible fiberoptic endoscopy

If unstable

Flexible Fiberoptic Endoscopy

Normal or Inconclusive

Feeding Difficulties?

Close Follow-up

Abnormal

Airway Films / Swallow Studies

Progressive or Persistent Symptoms

Resolution of Symptoms

1) Direct Laryngoscopy
2) Bronchoscopy
3) Treatment if applicable
4) Secure Airway if unstable

Interval Flexible Endoscopy or Airway Films

Differential Diagnosis

Overview

Table 2
Differential diagnosis of airway obstruction based on location and age of the child

	Birth to 1 year old	1–3 years old	3–6 years old
Nasopharynx and pharynx	• Choanal atresia/stenosis • Craniofacial abnormalities • Piriform aperture stenosis • Nasal stenosis • Neonatal rhinitis	• Adenotonsillar hypertrophy • Allergic rhinitis • Foreign body	• Adenotonsillar hypertrophy • Adenoiditis • Allergic rhinitis • Foreign body
Larynx	• Laryngomalacia • Congenital cysts • Laryngeal webs • Vocal cord palsy • Subglottic stenosis (congenital & acquired) • Laryngeal cleft • Subglottic hemangioma • Reflux laryngitis	• Foreign body • Recurrent respiratory papillomatosis	• Recurrent respiratory papillomatosis • Foreign body • Epiglottitis
Trachea	• Tracheomalacia • Tracheal stenosis • Vascular compression	• Croup • Bronchiolitis • Foreign body	• Foreign body

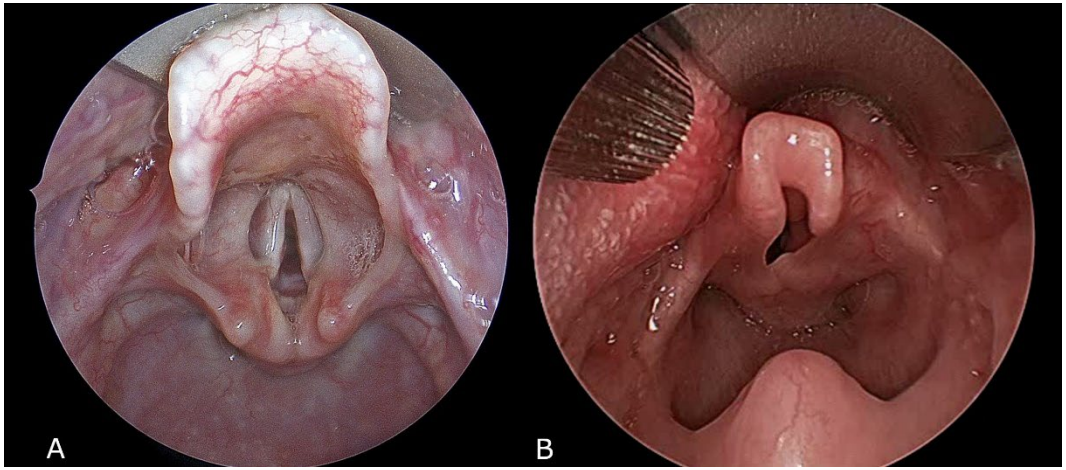
(Zalzal & Zalzal 2022)

Laryngomalacia

- Laryngomalacia is the most common cause of stridor in neonates and infants
- Most cases follow a relatively benign course
- The incidence of severe laryngomalacia resulting in persistent stridor with failure to thrive symptoms is about 10-15%.

Laryngomalacia: Pathophysiology and History

- Laryngomalacia was first described as having three basic abnormalities (Barthez & Rilliet 1853)
  1. Elongated epiglottis that prolapses posteriorly with inspiration
  2. Short aryepiglottic folds
  3. Redundant supra-arytenoid mucosa that prolapses anteriorly



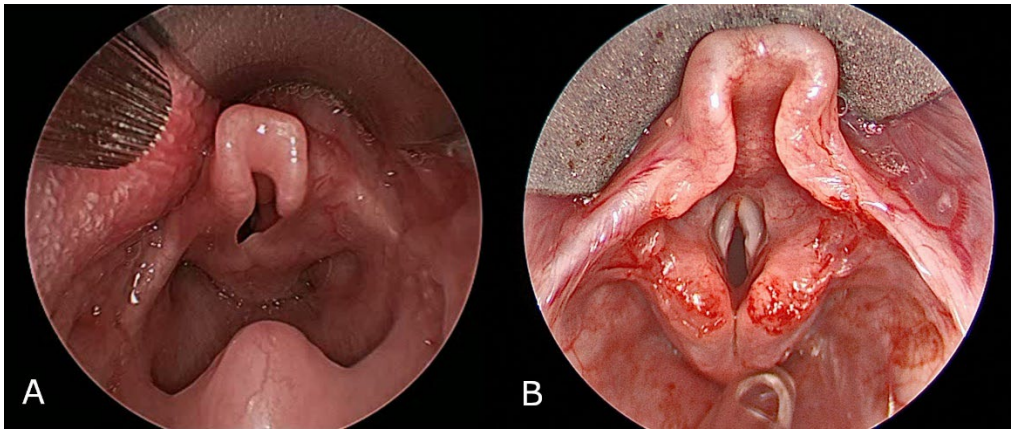
Laryngomalacia: Conservative & Medical Treatment

- Majority of laryngomalacia will resolve without surgery within 12-24 months of age
  - Routine follow-up is needed to rule out interval worsening of symptoms or apnea episodes

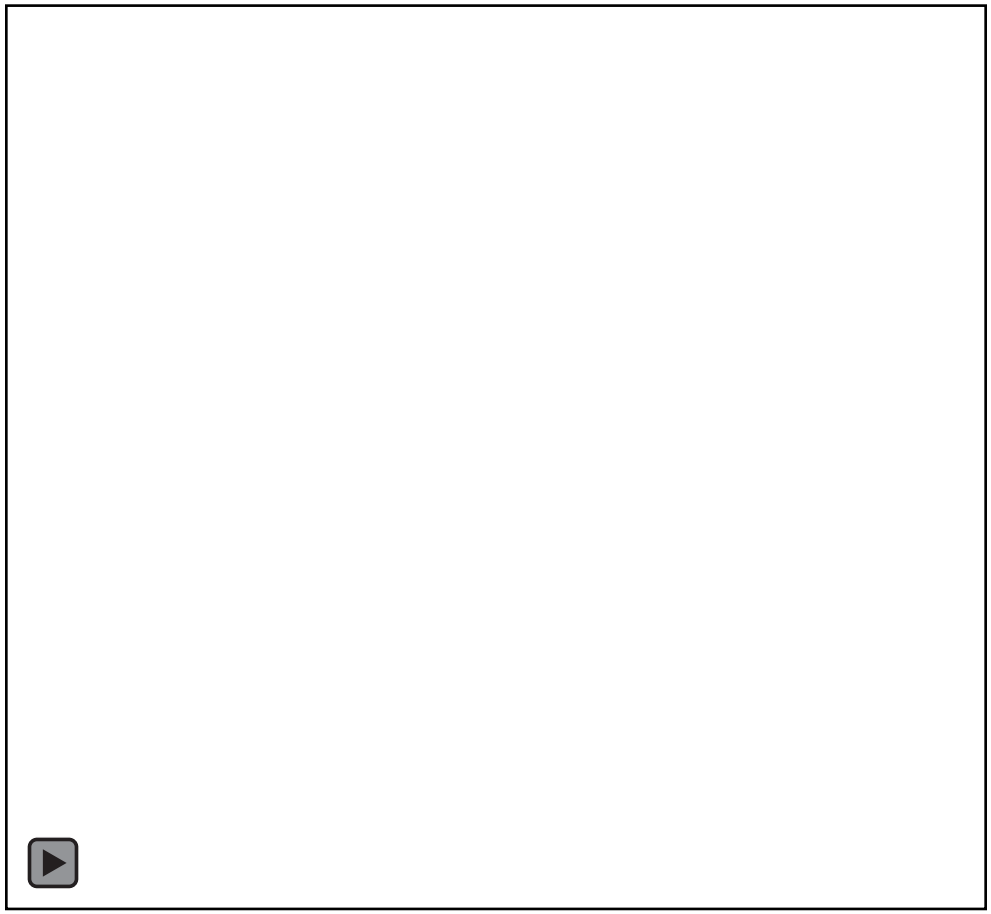
- Medications have been helpful
  - Acid reflux medications (H_2 blockers & PPI)
    - Recently, safety concerns have linked acid reflux medications to cancer and dementia in adults after long term use
    - Inconclusive right now if shorter courses of the medication are associated with adverse effects (no link determined)

Laryngomalacia: Supraglottoplasty (Primary)

- Up to 10% of children with laryngomalacia will require surgical management due to severe disease.
- Supraglottoplasty is the treatment of choice over the last four decades
  - Basic principles have remained the same, but the tools for the technique have changed



Laryngomalacia: Supraglottoplasty Video



Children's National

Laryngomalacia: Supraglottoplasty Outcomes

- Overall, success rates following supraglottoplasty range from 53% to 95% (Reddy 2001)

- Success depends on the indication for surgery
  - Typically, respiratory status (stridor) and feeding problems

Table 1. Major Indications for Supraglottoplasty in 106 Study Subjects

Indicator*	No. of Subjects
OSA	80
FTT	15
A/B/C	9
Cyanosis during feedings	2

**OSA indicates obstructive sleep apnea; FTT, failure to thrive; and A/B/C, apnea/bradycardia/cyanosis.*

Laryngomalacia: Post-Operative Failure

- Supraglottoplasty failures are attributable to:
  1. Failure to resect enough tissue (technical)
  2. Comorbid conditions / poor clinical picture (idiopathic)

- Complications from supraglottoplasty are rare.
  - In most series, the rate is below 10%.
  - The most common long-term complication is aspiration

Laryngomalacia: Post Operative Management

- IPOG Consensus Recommendations (Carter 2016)
  1. Proton pump inhibition or histamine-2 receptor antagonists should be continued for at least 3 months post-operatively
  2. 24 hours post-operative ICU-level monitoring in the event laryngeal edema worsens in that time frame.
- Swallowing outcomes should not be affected if supraglottoplasty performed correctly
- Routine follow-up ~4-6 weeks post-operatively

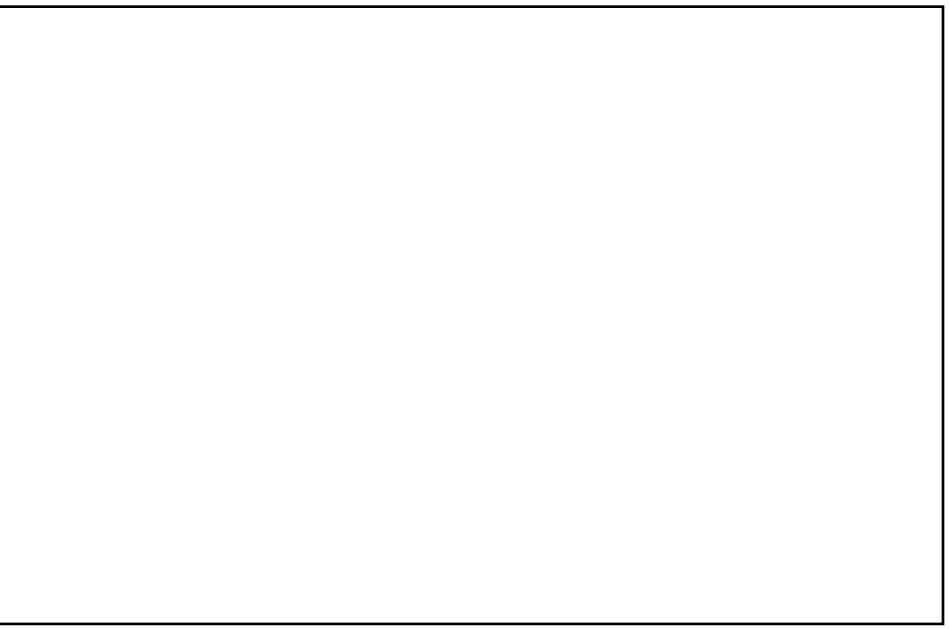
Vocal Cord Paralysis

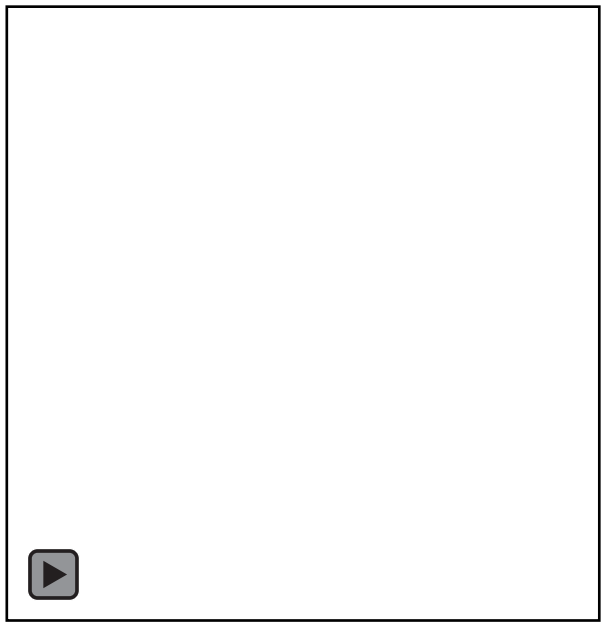
- Unilateral Vocal Cord Paralysis
  - Potential etiologies:
    - Birth trauma
    - Thoracic disease or procedures
    - Central or peripheral neurologic disease
    - Idiopathic
  - Presentation:
    - Weak cry or stridor
    - Aspiration, dysphagia or feeding difficulties
    - Voice is quiet and gains strength with time

Vocal Cord Paralysis

Flexible Laryngoscopy

Direct Laryngoscopy



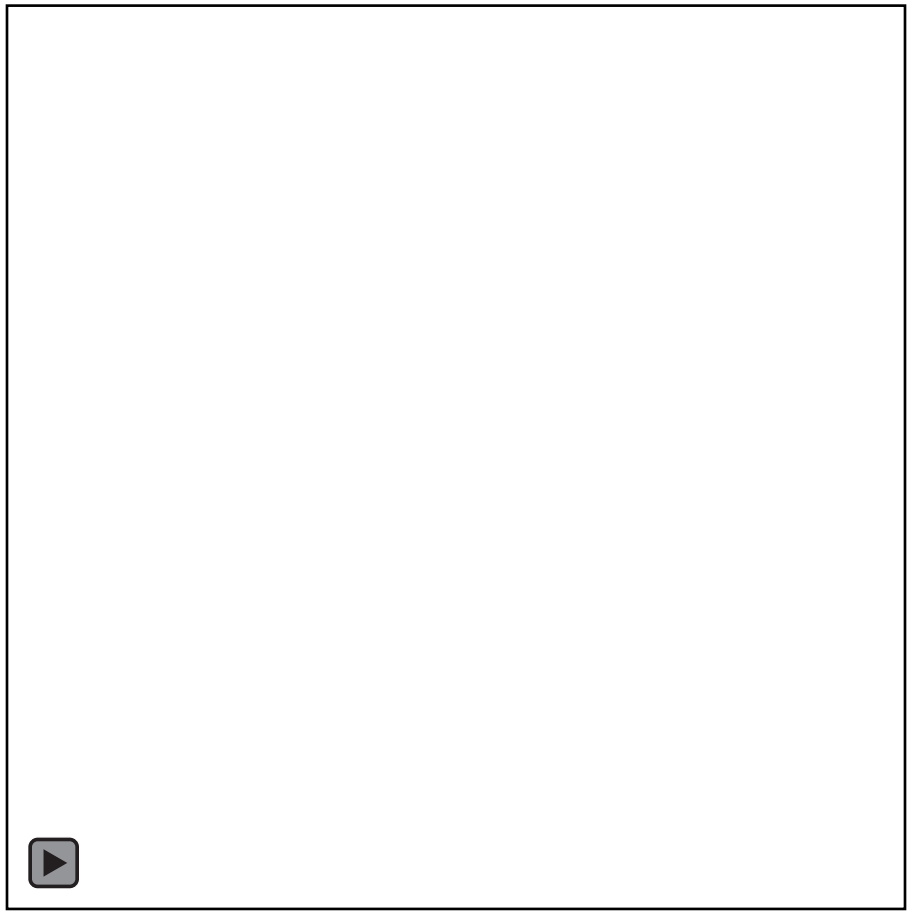


Children's National

Vocal Cord Paralysis

- Bilateral Vocal Cord Paralysis
  - Etiology
    - Brainstem malformations
    - Associations with genetic syndromes
    - History of Esophageal atresia repair
  - Most commonly diagnosed due to acute airway distress
  - Up to 73% of children may require tracheostomy placement (typically reported around 50%)

Vocal Cord Paralysis

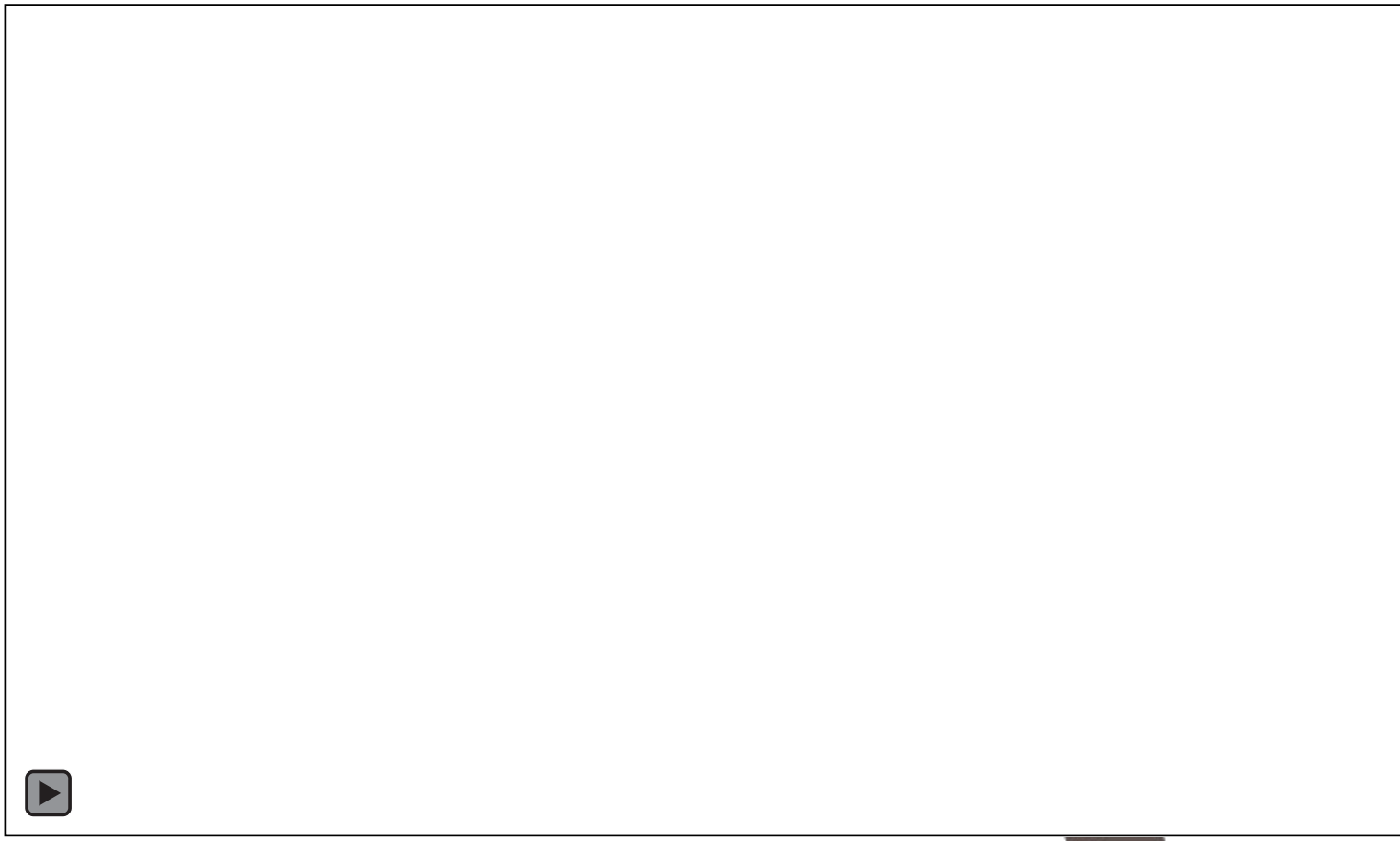


Vocal Cord Paralysis

- Diagnostic
  - Direct Visualization (endoscopy)
  - Feeding Trials
    - Trial of FEES or Barium Swallow
    - Many babies can compensate on their own; some may require short-term NG feeding or gastrostomy tube
  - Imaging (MRI to rule out compression)
    - If unknown etiology, recommend MRI brain/neck/chest

Vocal Cord Paralysis

Fiberoptic Endoscopic Evaluation of Swallowing



Video credit: Pamela Mudd, MD
Children's National Hospital

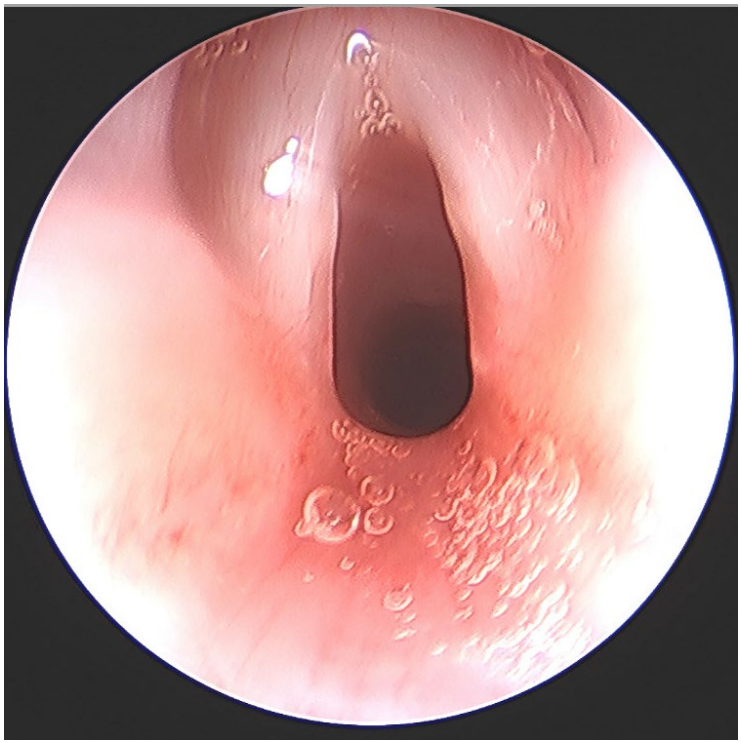
Children's National

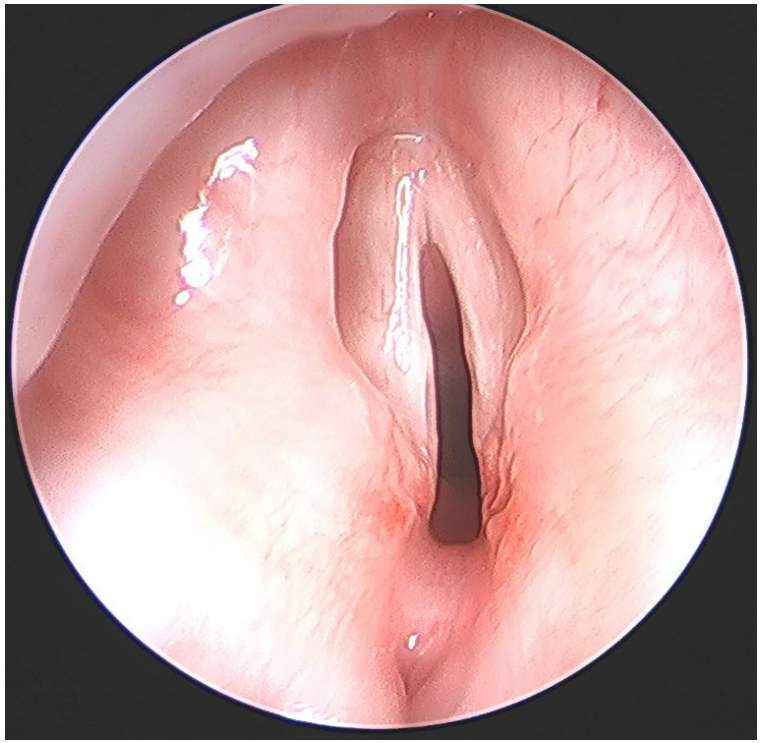
Vocal Cord Paralysis

- Management
  - Conservative
  - Vocal Cord Injection (for Unilateral, reversible)
  - Vocal Cord Lateralization (Reversible)
  - Glottic / Supraglottic Procedures
    - Arytenoidectomy/Posterior cordotomy
    - Endoscopic cricoid split
  - Tracheostomy (Reversible)

Vocal Cord Paralysis

- Vocal Cord Injection (Pre- and Post-Injection)

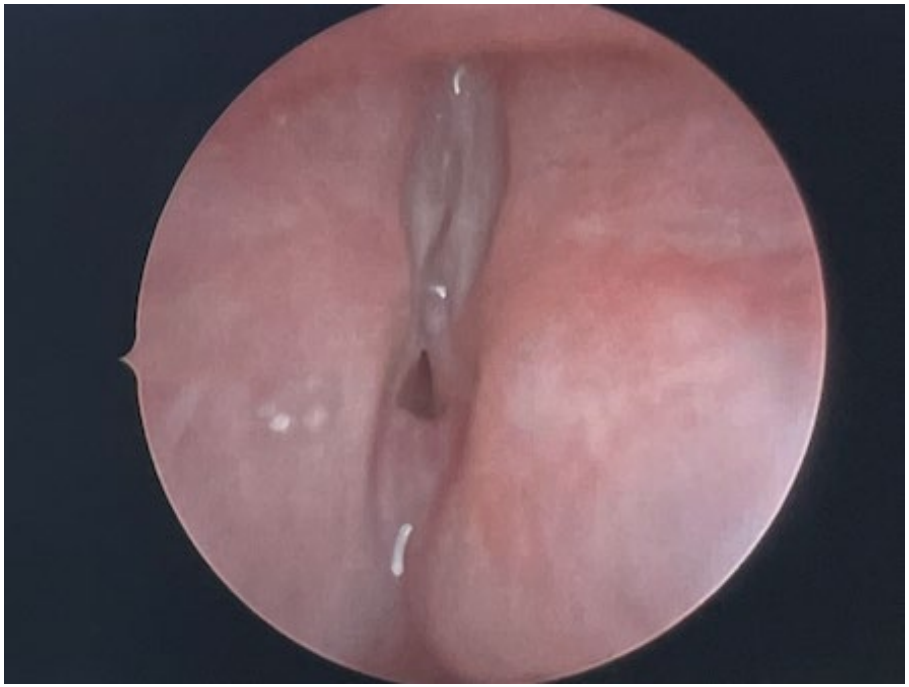


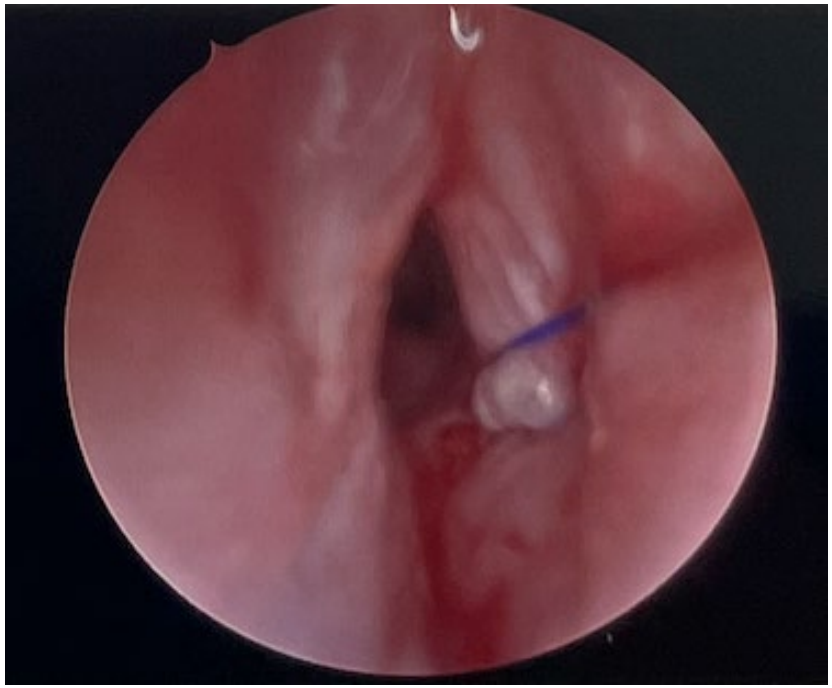


Video credit: Pamela Mudd, MD
Children's National Hospital

Vocal Cord Paralysis

- Vocal Cord Lateralization (Pre- and Post-Suture)



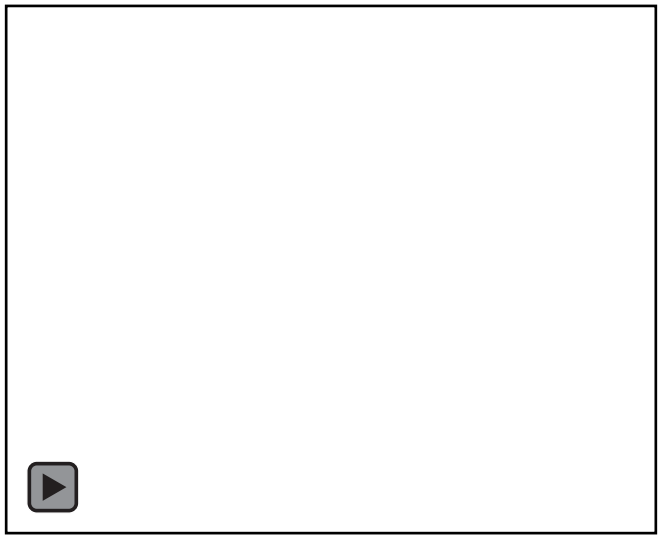


Video credit: Pamela Mudd, MD
Children's National Hospital

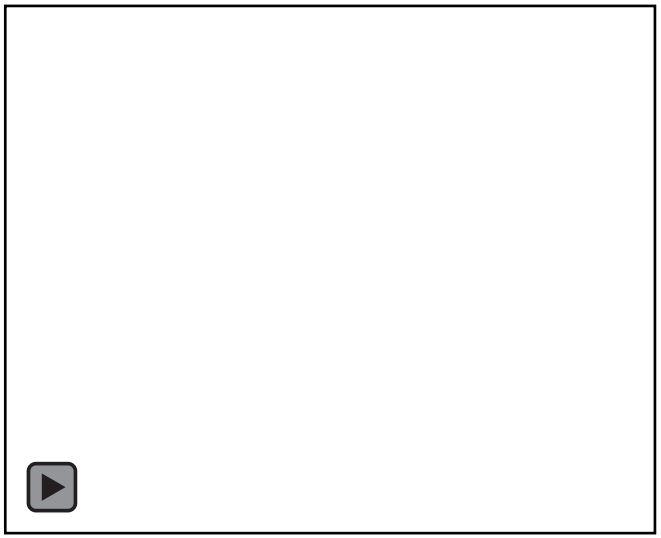
Subglottic Stenosis

- Circumferential narrowing of the trachea below the glottis
- Etiology: Acquired (MC) versus congenital (Rare)
  - Duration of intubation and endotracheal tube size are directly related to severity of acquired subglottic stenosis
  - Premature infants tend to tolerate longer periods of endotracheal tube intubation
- Four reasons the subglottis is most injured:
  1. Cricoid cartilage is the only complete circular cartilaginous ring
  2. The epithelium is delicate and prone to injury
  3. Subglottic mucosa consists of loose areolar tissue
  4. Subglottis is the narrowest portion of the pediatric airway

Subglottic Stenosis

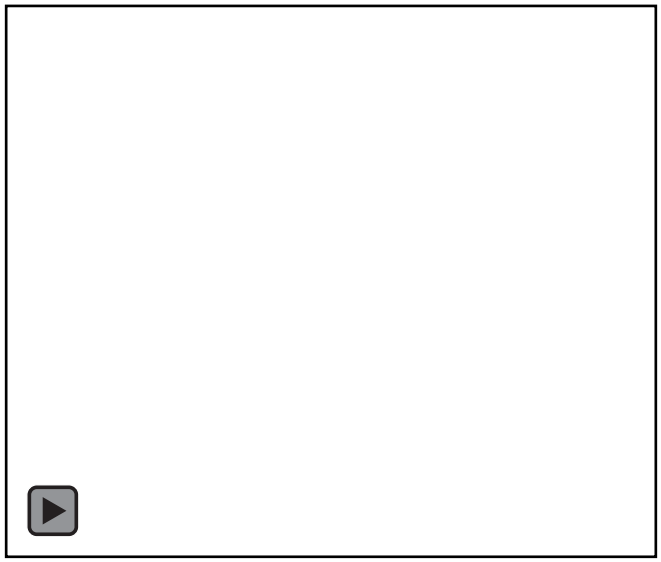


Grade 1: 0-50%

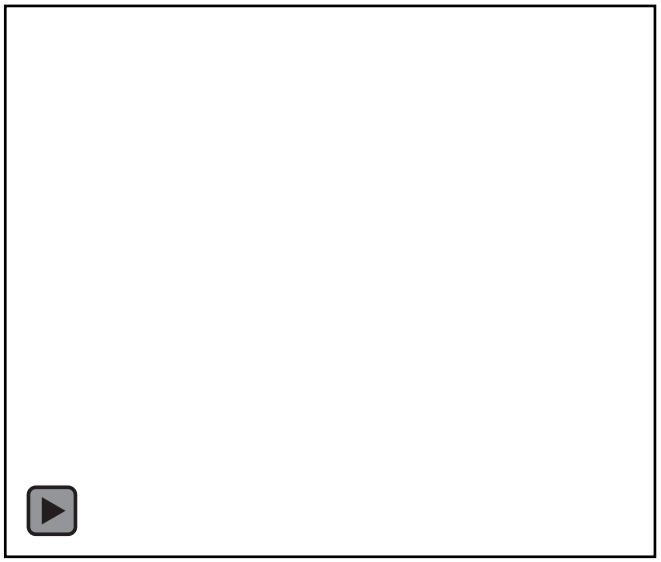


Grade 2: 51-70%

Subglottic Stenosis



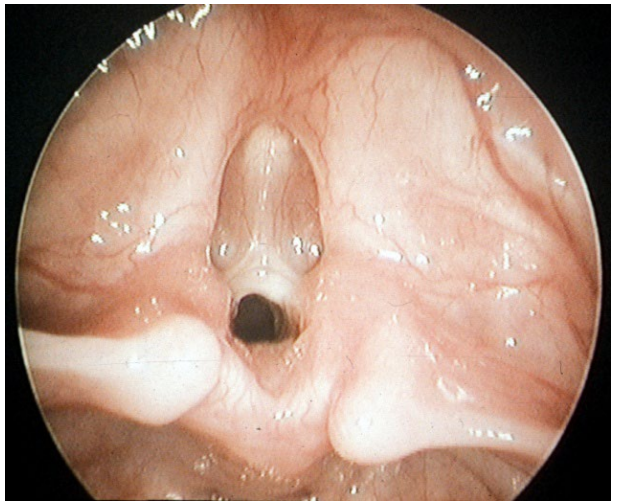
Grade 3: 71-99%



Grade 4: 100%

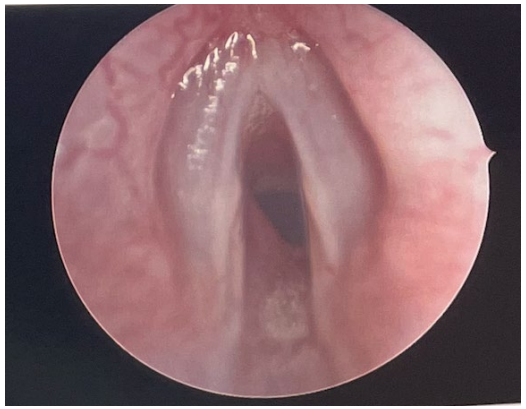
Laryngeal Web

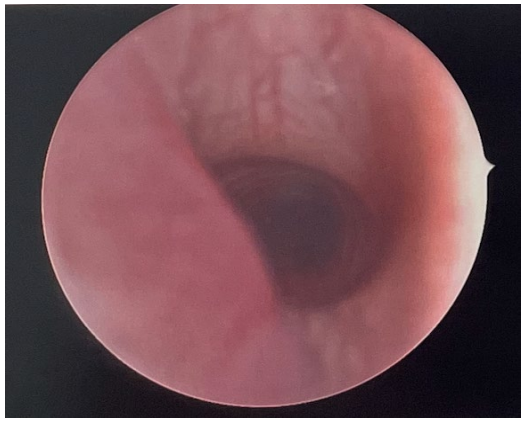
- Rare anomalies typically presenting as stridor or aphonia in neonatal population
- Anterior webs associated with:
  - Cardiac anomalies
  - DiGeorge Syndrome
- Cohen Classification
  - Associated with subglottic stenosis
  - Most severe is laryngeal atresia
    - Incompatible with life
- Diagnosis: Flexible or Rigid Endoscopy
- Treatment:
  - Small webs treated endoscopically with lysis
  - Larger webs require open approach alongside tracheotomy



Subglottic Hemangioma

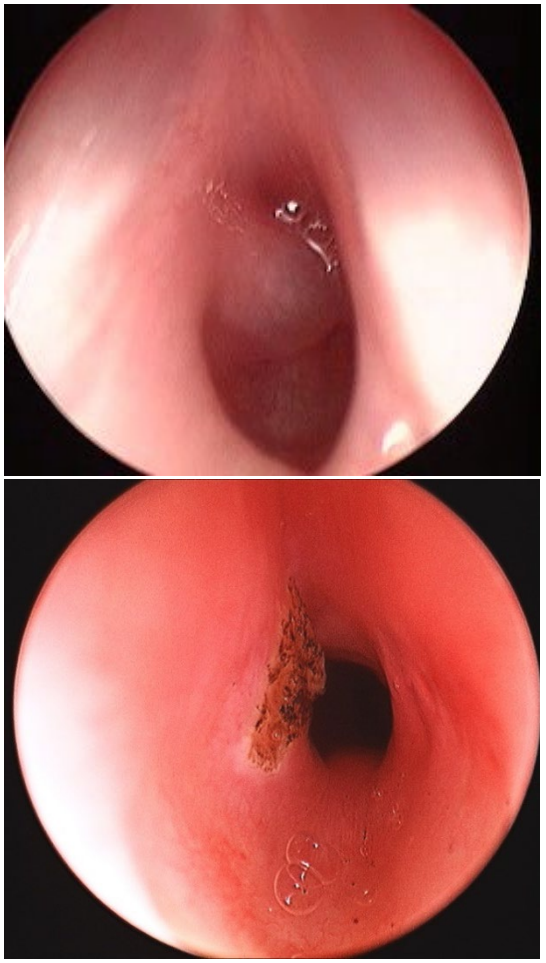
- Typically present in infancy
  - Found on the left in the subglottis
- Progression
  - Tend to be absent at birth
  - Peak size between 4-6 months
- Concern for subglottic hemangioma should arise when anterior neck lesions are present
- Treatment:
  - Historically: Steroids and laser excisions
  - Modern: Propranolol therapy is currently first line treatment





Subglottic Cysts

- Presentation is similar to subglottic stenosis or subglottic hemangioma
- Intubation trauma likely source of these lesions
- Treatment:
  - Surgical with marsupialization or laser excision



Tracheomalacia

- Dynamic problem; More common in premature infants
- Presentation may consist of cough, frequent respiratory infections, cyanotic episodes
- Should improve in first 6-12 months of life
- If tracheomalacia is secondary to vascular compression, surgical correction of underlying cardiac anomaly can improve tracheomalacia

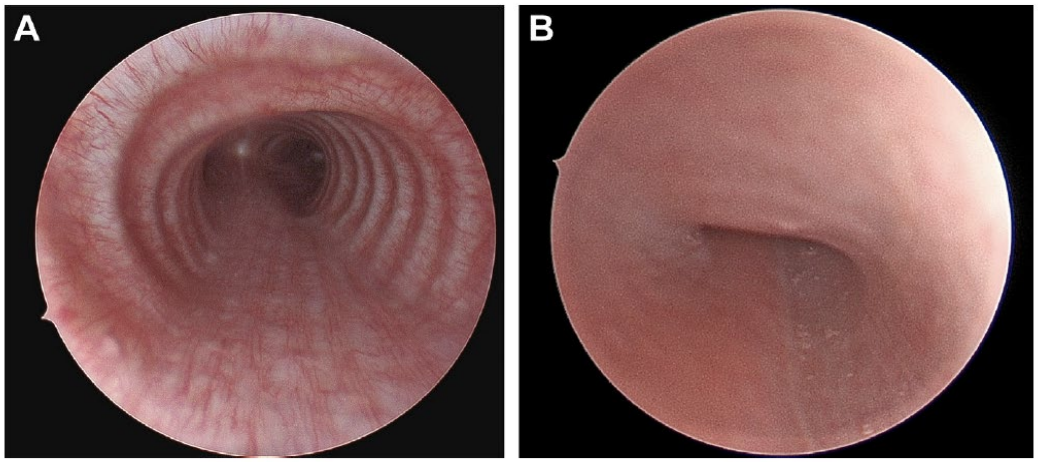


Fig. 6. Appearance of normal distal trachea (*A*) and severe tracheomalacia (*B*).

Children's National

Conclusion & Take Away Points

1. Identify duration and severity of stridor if respiratory distress is present on physical exam
2. Laryngeal examination with endoscopy is gold standard for evaluation in stable patient
   - If the patient is unstable, will require endoscopic evaluation under anesthesia prior to intubation, if possible.
3. Chronic stridor is most commonly secondary to laryngomalacia in otherwise healthy children
   - Most patients (90%) resolve with observation or medical management.

References

- Allen, SA. "Neonatal Stridor". Joe DiMaggio Children's Hospital Grand Rounds. July 28 2022. Hollywood, FL. Lecture.
- Barthez E. Traité clinique et pratique des maladies des enfants: Germer Baillière; 1853
- Bedwell, J. *Diagnosing a Noisy Breather: Stridor in Infants.* *https://www.texaschildrens.org/sites/default/files/uploads/Joshua%20Bedwell.pptx*. Powerpoint Presentation
- Carter J, Rahbar R, Brigger M, Chan K, Cheng A, Daniel SJ, et al. International Pediatric ORL Group (IPOG) laryngomalacia consensus recommendations. Int J Pediatr Otorhinolaryngol. 2016;86:256-61.
- Reddy DK, Matt BH. Unilateral vs. bilateral supraglottoplasty for severe laryngomalacia in children. Arch Otolaryngol Head Neck Surg. 2001;127(6):694-9.
- Zalzal, H. G., & Zalzal, G. H. (2022). Stridor in the infant patient. *Pediatric Clinics of North America*, 69(2), 301–317. https://doi.org/10.1016/j.pcl.2021.12.003

Children's National

Thank You!

Children's National