Pediatric Airway

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Grand Rounds Presentation
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Introduction
Airway Concerns

- Trouble Breathing
- Anywhere from nose to lungs
- Neonates are obligate nasal breathers
- Nasal symptoms:
  - Classic cyclical cyanosis
  - Grunting/Nasal Flaring
  - Mouth breathing
  - Snoring
# Table 78.1

## Signs and Symptoms of Airway Obstruction by Location

<table>
<thead>
<tr>
<th>Region</th>
<th>Voice</th>
<th>Stridor</th>
<th>Retractions</th>
<th>Feeding</th>
<th>Mouth</th>
<th>Cough</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oropharyngeal obstruction</td>
<td>Unaffected but can be throaty or full</td>
<td>Inspiratory and coarse; increases during sleep</td>
<td>Sternal and intercostal, increasing to total chest when severe</td>
<td>Difficult to impossible, with drooling or saliva</td>
<td>Open; jaw held forward</td>
<td>None</td>
</tr>
<tr>
<td>Supraglottic laryngeal obstruction</td>
<td>Muffled or throaty</td>
<td>Snoring; inspiratory; fluttering</td>
<td>None, until very late</td>
<td>Difficult to impossible</td>
<td>Open; jaw held forward</td>
<td>None</td>
</tr>
<tr>
<td>Glottic obstruction</td>
<td>Hoarse or aphonic</td>
<td>Inspiratory early; expiratory also as obstruction increases</td>
<td>Xiphoid early and intercostal later; suprasternal and supracleavicular</td>
<td>Normal, except with severe obstruction</td>
<td>May be closed; nares flared</td>
<td>None</td>
</tr>
<tr>
<td>Subglottic obstruction</td>
<td>Hoarse, but can be husky or normal</td>
<td>Inspiratory early; expiratory also as obstruction increases</td>
<td>Xiphoid early and intercostal later; suprasternal and supracleavicular</td>
<td>Normal, except with severe obstruction</td>
<td>May be closed; nares flared</td>
<td>Barking</td>
</tr>
<tr>
<td>Tracheobronchial obstruction</td>
<td>Normal</td>
<td>Expiratory and wheezing; becoming to and fro with increasing obstruction</td>
<td>None, except with severe obstruction; xiphoid and sternal</td>
<td>Normal, except with severe airway obstruction or when extrinsic obstruction involves esophagus</td>
<td>May be closed; nares flared</td>
<td>Brassy</td>
</tr>
</tbody>
</table>

Airway Concerns

Stridor and Laryngeal Pathology
Laryngeal Obstruction

- Most common site of stridor

- Symptoms
  - Difficulty with Respiration, Phonation, and Swallowing
  - Episodes of Aspiration
  - Suprasternal and intercostal retractions
## Obstruction

<table>
<thead>
<tr>
<th>Glottic</th>
<th>Subglottic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Symptoms:</strong></td>
<td><strong>Symptoms:</strong></td>
</tr>
<tr>
<td>* Stridor – inspiratory or biphasic if severe</td>
<td>* Hoarse cry</td>
</tr>
<tr>
<td>* Abnormal Cry</td>
<td>* Inspiratory stridor which progresses to biphasic stridor as obstruction increases</td>
</tr>
<tr>
<td>* Feeding difficulty</td>
<td>* Barking cough</td>
</tr>
<tr>
<td>* Aspiration</td>
<td>* Xiphoid retractions and Alar flaring in severe obstruction</td>
</tr>
</tbody>
</table>
Supraglottic Obstruction

- Laryngomalacia
- Vallecular Cyst
- Saccular Cyst
- Supraglottic Webs
Glottic Obstruction

- Vocal Cord Paralysis
- Webs
- Laryngeal Stenosis
- Laryngeal Cleft
- Neoplasm
- Laryngospasm
Infectious Causes
Croup

- 6 months to 6 years - #1 cause of upper airway obstruction

- Agent: Parainfluenza Virus

- Presents with hoarseness, barking cough, and stridor

- Recurrent Croup
  - 3+ infections
  - Anatomical Issues
  - Allergy/Asthma Issues

| TABLE I
<table>
<thead>
<tr>
<th>LARYNGOBRONCHOSCOPY FINDINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finding</td>
</tr>
<tr>
<td>Laryngopharyngeal reflux</td>
</tr>
<tr>
<td>Subglottic stenosis</td>
</tr>
<tr>
<td>Laryngomalacia</td>
</tr>
<tr>
<td>Bronchomalacia</td>
</tr>
<tr>
<td>Tracheomalacia</td>
</tr>
<tr>
<td>Vascular compression of distal trachea</td>
</tr>
<tr>
<td>Stenosis of left main bronchus</td>
</tr>
<tr>
<td>Subglottic cyst</td>
</tr>
</tbody>
</table>

Epiglottitis

- Decreasing in Frequency
- Agent: H. influenza (although increasing cases noted of S. pneumoniae)
- Diff Dx: Laryngitis
- Presents with fever, sore throat, and respiratory distress progressing to odynophagia and stridor
Tracheitis

∗ Typical History of URI over course of several days

∗ Agent: S. aureus

∗ Symptoms:
  ∗ High Fever
  ∗ Acute Rapid Deterioration
  ∗ Inspiratory and possible biphasic stridor

Increasing causes of tracheitis include H influenza, s pneumococcus, and moraxella/branhamella catarrhalis
Tracheitis

Management:
- Lateral View Neck XR
- Attempt FOL
- Prepare to secure airway if impending failure
- DL/DB with culture
- IV ABX then PO ABX once culture-guided

A 4 year old child with hoarseness and audible breathing is referred to you for evaluation. He has been unresponsive to allergy, asthma, and reflux treatment. On FOL, there is some anomaly so you take the child to the OR and perform a DL showing the following image.

Which of the following is false regarding this disease?

A. Typically benign but with a 1% chance of malignant transformation

B. Due to HPV 6 and 11

C. Will require serial surgeries to debulk

D. Tracheotomy should be performed early in management
Question

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B. Due to HPV 6 and 11

C. Will require serial surgeries to debulk

D. Tracheotomy should be performed early in management
Recurrent Respiratory Papillomatosis

* Symptoms:
  * Hoarseness
  * Audible breathing to stridor
  * Chronic cough
  * Dyspnea
  * Dysphagia

* Agent: HPV 6 & 11

* Concern for malignant transformation

HPV 6 and 11 tend to count for at minimum 50% of all cases and often up 100% in several series. Mumps vaccine, cruciferous veggies, indole 3 carbinol have all been tried in addition to cidofovir and IFN alpha with minimal benefit thus far. PDT laser has shown better response than CO2 laser. Delay a trach until the last possible time as the virus can seed the trach path and spread.

Supraglottic Concerns
You are called to evaluate a 4 month old with poor feeding with frequent coughing but gaining weight, weak cry, and noisy breathing. You have already brought the PINE tower with you. You decide to scope right then and there and see the following.
Question

You re-assure the parents by telling them the diagnosis. They ask you what should they do next. You say that while there are many thoughts out there, you would suggest?

A. Reassurance that the problem is mild
B. Treatment with Prevacid
C. Surgical Intervention
D. Observation as this disease is typically self-limited
Question

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A. Reassurance that the problem is mild
B. **Treatment with Prevacid**
C. Surgical Intervention
D. Observation as this disease is typically self-limited
Laryngomalacia

- Most common cause of stridor in infancy (45% or greater)
- Peaks in the weeks to couple of months after birth
- Typically resolves by 12-18 months
- Presents with poor feeding, weak cry, and stridor
**Laryngomalacia**

- Classified from mild to moderate to severe
  - Mild = inconsequential stridor
  - Moderate = inspiratory stridor causing feeding-related symptoms
  - Severe = severe stridor refractive to medical therapy and/or causing failure to thrive

- Exact etiology unknown

**NOTES**: Etiology likely is a combination of neurologic issues (unable to coordinate the suck swallow breathe sequence) vs cartilage weakness which is abnormally pliable vs anatomic theory of excess flaccid tissue that is susceptible to obstruction during inspiration.
Laryngomalacia

**Treatment**

- **Observation:**
  - May be outgrown by 8 months of age

- **Medication:**
  - Anti-Reflux Therapy

- **Surgical:**
  - Supraglottoplasty

---

Anti-reflux therapy can start at 3mg/kg 3 times a day, some suggest prevacid solutabs. Infants can remain on medical therapy for up to 9 months if needed and receiving appropriate benefits.

_A systematic review of supraglottoplasty outcomes._

_Preciado D, Zalzal G._

Landry AM, Thompson DM. Laryngomalacia: Disease presentation, spectrum, Management. 2012
Laryngomalacia

Is Supraglottoplasty Underutilized?

David R. White, MD

| TABLE I. Comparison of Adenotonsillectomy and Supraglottoplasty. |
|---------------------------------|---------------------------------|
|                                | Adenotonsillectomy | Supraglottoplasty |
| Success rate                   | 60%-85%            | 85% or better     |
|                                | (Defined as normalization of obstructive apnea-hypopnea index) | (Defined as normalization of breathing and feeding) |
|                                | (Worse in predictable populations) | (Worse in predictable populations) |
| Polysomnography outcomes       | Significant improvement in most measurements | Significant improvement in most measurements |
| Average recovery time           | 4-7 days           | <24 hours         |
| Postoperative pain             | Substantial       | Minimal           |
| Postoperative hemorrhage       | 2%                 | Minimal, no reported complications |
| Other postoperative complications | Transient velopharyngeal insufficiency approximately 15% | Transient aspiration approximately 15% |
|                                | Persistent velopharyngeal insufficiency <1% in otherwise normal patients | Persistent aspiration <1% in otherwise normal patients |
| Perioperative mortality        | 1/15,000           | Unknown (no data) |
| Postoperative monitoring       | Outpatient         | Overnight stay in intensive care unit |
| Average patient                | Healthy child      | Infant with failure to thrive, mild respiratory distress |
Cysts

- Incredibly Rare
- Saccular
- Distension of laryngeal ventricle mucosa
- Anterior vs Lateral
- Airway
- Vallecular
- Obstruction of submucosal salivary duct
- Feeding

NOTES: Cysts are ridiculously rare – seen in 1-2 children in 100000 (the highest reported rate); an anterior cyst grows and lead to obstruction sooner while more posterior and lateral cysts enlarge and then pierce through the thyrohyoid membrane and cause a neck mass;
Glottic Concerns
Laryngeal Web

- **Congenital**
  - Secondary to incomplete recanalization of larynx

- **Acquired**
  - Intubation
  - Infection
  - Trauma/iatrogenic

- **Symptoms**
  - Range from weak cry to stridor
  - Respiratory distress may be present as well
  - Recurrent croup
Laryngeal Web

NOTES: This is Cohen’s classification – mainly accounts for glottic opening. 0-35, 35-50, 50-75, 75-99. Benjamin’s classification adds an aspect by giving a grade based on location – Glottic web, subglottic web, supraglottic web, and interarytenoid fixation.
Laryngeal Web

* Observation
  * Small anterior web
  * No respiratory or voice problems

* Endoscopic
  * Small web
  * Thin web without subglottic extension
  * KTP Laser with Mitomycin C

Laryngeal Web

- External and/or endoscopic approach
  - Laser
  - Microsurgical Flap creation
  - Stent placement

- LTR with anterior cartilage graft
  - Anterior web with subglottic extension

Laryngeal Cleft

- Rare Congenital Lesion
- First described in 1972
- Due to incomplete fusion of Tracheobronchial Groove
- Slightly favors males than females
- Prematurity and Polyhydramnios increase risk
- Associated with VACTERL syndrome

NOTES: Grooves typically meet and fuse in midline by week 6 of life. Cricoid cartilage starts to form at week 5 and usually completes chondrification by week 6 as well. Failure of either the fusion or the chondrification can lead to TEF or laryngeal cleft.
Laryngeal Cleft

What grade cleft is this – the metal piece marks the inferior depth of the cleft?

A. Grade I
B. Grade II
C. Grade III
D. Grade IV
Laryngeal Cleft

What grade cleft is this – the metal piece marks the inferior depth of the cleft?

A. Grade I
B. **Grade II**
C. Grade III
D. Grade IV
Laryngeal Cleft

- **Symptoms:**
  - Asymptomatic
  - Hoarseness
  - Mild to severe Aspiration
  - Recurrent pulmonary infections
  - Regurgitation
  - Infrequently stridor

- Diagnosed on Endoscopy following suspicion on Barium Swallow

**Type 1:** limited to the interarytenoid region, above level of true vocal folds

**Type 2:** cricoid lamina is partially involved, with extension below level of true vocal folds

**Type 3:** total cricoid cleft, extends completely through cricoid cartilage with or without further extension into cervical trachea

**Type 4:** extends into posterior wall of thoracic trachea and may extend as far as carina
Laryngeal Cleft

- Grade I and II
  - Start with anti-reflux meds and thickened feeds
  - If resistant, endoscopic approach with laser

- Grade II and higher
  - Anterior open approach via laryngofissure
  - Lateral Pharyngotomy approach

NOTES: Tibial periosteum can be used as the interposition graft or fascia depending on the extent of the cleft.
Vocal Cord Paralysis

*Bilateral Paralysis*
- Rare
- Presents early – either at birth or after inciting event
- Immediate airway obstruction

*Unilateral Paralysis*
- Slightly less rare
- Symptoms:
  - Noisy breathing
  - Feeding Difficulty
  - Hoarseness
Unilateral Vocal Cord Paralysis

- Presentation changes with age
- Neonates/Infants
  - Poor feeding
  - Weak cry
  - Cyanosis if severe
  - Aspiration
- Older children/Adolescents
  - Hoarseness
  - Poor Vocal projection
Unilateral Vocal Cord Paralysis

Causes:
- Traumatic delivery – Need for Forceps
- CNS malformation – Arnold-Chiari
- Cardiovocal Syndrome = Thoracic Vascular or Cardiac Anomalies + Congenital Left VCP
- Iatrogenic
  - PDA ligation, TEF repair, Esophageal Atresia Repair
- Infectious
  - Lyme Disease, EBV, Polio
- Neoplasms and Chemotherapy
- Idiopathic – nearly 50% of children with UVCP

Unilateral Vocal Cord Paralysis

 Thoughts in Management:

* Flexible Laryngoscopy
* MRI of the Brain down to the Thoracic Inlet
* Laryngeal EMG
  * Strong predictive role
  * No normal action potentials after 6 months ~ highly indicative
  * Useful in iatrogenic complications

NOTES: MRI helps trace the course of the RLN.

Unilateral Vocal Cord Paralysis

- Rule out concomitant lesions
- Is feeding an issue?
  - Speech therapy
  - Vocal Cord Injection
  - Re-innervation
  - Medialization
  - Thyroplasty

NOTES: Concomitant lesions include laryngeal webs, Crico-arytenoid fixation, subglottic stenosis, and vocal cord granulomas; laryngomalacia, tracheomalacia. Re-innervation has shown great promise because children readily learn to adapt with the working cord and gaining tone is all they need. Plus, this procedure can be done while the patient is asleep. Ansa has shown the greatest benefit so far in studies. Medialization may be considered in a child but should be deferred at minimum until puberty is completed.

Vocal Cord Granuloma

- Mild
  - Observation
  - Anti-Reflux Medication

- Severe
  - CO₂ laser treatment
Subglottic Concerns
Subglottic Hemangioma

- Manifests in first weeks to months of life
- Typically Unilateral
- Associated with cutaneous hemangiomas (typically 50%)
- Female preponderance
- Proliferative phase to Involution phase
Subglottic Hemangioma

* Symptoms:
  * Poor Feeding
  * Biphasic Stridor
  * Recurrent URI
  * Weak Cry
Subglottic Hemangioma

- Propranolol
  - Starting dose 1 mg/kg/day
  - Divided in 3 doses
  - Increase to 2 mg/kg/day on week 2
  - Monitor BP, pulse, and blood sugars
  - Monitor every 3 months with endoscopies
  - Wean off after 12 months

Subglottic Hemangioma

After 6 weeks of treatment, the child continues to have stridor, feeding difficulty, and respiratory distress, what can be done?

- Endoscopic Laser Resection
  - CO₂ Laser preferred
  - Best for Unilateral Lesions
  - Circumferential or Bilateral Lesions - Risk of subglottic stenosis (6-25%)
  - May need Tracheotomy

O-Lee TJ, Mesner A. Subglottic Hemangioma. Oto Clin N Am 2008; 41(5)
Subglottic Hemangioma

After 6 weeks of treatment, the child continues to have stridor, feeding difficulty, and respiratory distress, what can be done?

- Intra-lesional Steroid Injection
  - Typically reduces size rather than involute
  - May require prolonged intubation

- Open Excision via Cricoid Split

- Tracheotomy

O-Lee TJ, Mesner A. Subglottic Hemangioma. Oto Clin N Am 2008; 41(5)
Question

A 3-month old child presents to clinic with a history of recurrent croup. Fiberoptic Laryngoscopy reveals a subglottic hemangioma. In addition to management of the child’s airway, what would an additional step in management?

A. MRI Brain  
B. CT Chest  
C. EEG  
D. Genetic Screening  
E. CBC
A 3-month old child presents to clinic with a history of recurrent croup. Fiberoptic Laryngoscopy reveals a subglottic hemangioma. In addition to management of the child’s airway, what would an additional step in management?

A. **MRI Brain**

Due to finding of a subglottic hemangioma and a facial hemangioma in a beard-like distribution, this child is at high risk for having PHACES syndrome. A MRI will help rule out posterior fossa malformations and intracranial arterial malformations.
Subglottic Stenosis

- Congenital form – due to malformed cricoid cartilage – RARE!
- Acquired secondary to Intubation
- 1-2% of intubated children
- Associated Factors:
  - GERD
  - Malnutrition
  - Infection
  - Systemic Illnesses
Subglottic Stenosis

Association Between Length of Intubation and Subglottic Stenosis in Children

Denise Manica, MD, MSc; Cláudia Schweiger, MD, MSc; Paulo José Cauduro Maróstica, MD, PhD; Gabriel Kuhl, MD; Paulo Roberto Antonacci Carvalho, MD, PhD

- Study Design: Prospective
- Subjects: Age < 5yrs intubated for 24+ hours
- 142 children included and FFL performed following extubation and at least 1 week after
- Results: 50% increased risk of SGS with every 5 days of intubation & 12% increased risk of SGS with each additional day of sedation
A 1-year old child presents to clinic on referral from his pediatrician regarding frequent Croup infections. Upon examination of the child, you hear an audible biphasic stridor. You decide to perform a flexible fiberoptic laryngoscopy in clinic and see this image.
Subglottic Stenosis

<table>
<thead>
<tr>
<th>Classification</th>
<th>From</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade I</td>
<td>No Obstruction</td>
<td>50% Obstruction</td>
</tr>
<tr>
<td>Grade II</td>
<td>51% Obstruction</td>
<td>70% Obstruction</td>
</tr>
<tr>
<td>Grade III</td>
<td>71% Obstruction</td>
<td>99% Obstruction</td>
</tr>
<tr>
<td>Grade IV</td>
<td>No Detectable Lumen</td>
<td></td>
</tr>
</tbody>
</table>

*Figure 32-3. Myer-Cotton grading system for subglottic stenosis.*
Subglottic Stenosis

- Management
  - Anterior Cricoid Split
  - Laryngotracheal Reconstruction
  - Cricotracheal Resection
  - Balloon Dilation
  - Sliding Tracheoplasty
  - Tracheotomy
Subglottic Stenosis

- Grade I and mild Grade II
  - Observation

- Moderate Grade II
  - Endoscopic Approaches (Balloon Dilation and/or CO₂ laser)

- Persistent Stenosis and Grade III
  - Open approaches after securing airway (tracheotomy)
  - Laryngotracheal Reconstruction with cartilage grafts
Subglottic Stenosis

* Grade IV
  * Tracheotomy
  * Cricotracheal Resection

* Neonatal Procedures – Anterior Cricoid Split
  * Indications:
    * Multiple failed extubations
    * Off ventilator support for at least 10 days
    * Supplemental oxygen less than 30%
    * Weight greater than 1500 gm

Cotton RT. Management of Subglottic Stenosis.
Subglottic Stenosis

- Balloon Dilation
  - Considered first-line with regards to therapy in lower Cotton-Myer grade stenosis
  - May be utilized in conjunction with Steroid Injections or Topical Mitomycin C
  - Favor open surgical approach if no improvement after three times
  - Increased failure rates if concomitant airway disease present

Conclusion
# Other Causes

<table>
<thead>
<tr>
<th>Supraglottic larynx</th>
<th>Laryngomalacia</th>
<th>Epiglottitis (supraglottitis)</th>
<th>Hemangioma</th>
<th>Foreign body</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laryngocele or sacellar cyst</td>
<td>Angioneurotic edema</td>
<td>Papilloma</td>
<td>Lymphangioma</td>
<td>Vocal cord paralysis</td>
</tr>
<tr>
<td>Glottic larynx</td>
<td>Web or atresia</td>
<td>Laryngitis</td>
<td>Hemangioma</td>
<td>Hematoma</td>
</tr>
<tr>
<td>Laryngeal cleft</td>
<td>Spasm</td>
<td>Lymphangioma</td>
<td>Papilloma</td>
<td>Fracture</td>
</tr>
<tr>
<td>Stenosis</td>
<td>Stenosis</td>
<td>Papilloma</td>
<td>Granuloma</td>
<td>Foreign body</td>
</tr>
<tr>
<td>Subglottic larynx</td>
<td>Stenosis</td>
<td>Croup (viral laryngotracheobronchitis)</td>
<td>Hemangioma</td>
<td>Chondritis</td>
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<tr>
<td>Cysts</td>
<td>Stenosis</td>
<td>Papilloma</td>
<td>Stenosis</td>
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