Pediatric Respiratory Emergencies
Acute upper and Lower airway obstruction in children

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Atlantic Health System
General Category of Pediatric Respiratory Emergencies

- Upper airway obstruction
- Lower airway obstruction
- Lower respiratory tract infections/Injury
Introduction

- Acute upper airway obstruction from any cause can be a life-threatening emergency.

- Complete obstruction will result in respiratory failure followed by cardiac arrest, in a matter of minutes.

- A child with a partial obstruction may have an adequate airway initially. However, this condition can deteriorate rapidly.
What is the difference between peds and adult airways?

Children are susceptible to infections to which they are not previously been exposed and acquired immunity.

• A proportionally larger head
• A more prominent occiput
• A relatively laxer cervical support
• A relatively larger tongue

The airway is narrowest at subglottic level the covering connective tissue is loosely attached.

Airflow is proportional to $r^4$, an airway $r$ of 3.5 mm that develops 0.5 mm of edema shows a reduction of flow to 54% from baseline

$3.5^4 = 150$

$3^4 = 81$

Respiratory muscles in young children are less efficient, and fatigue can develop quickly, leading to respiratory failure and apnea.

Lung volume at FRC is similar to closing volume in infants, increasing tendency to small airway closure and hypoxia.

The chest wall is very compliant, increased respiratory effort leads to marked chest wall recession, with decrease in the efficiency of breathing.
Common symptoms and signs of respiratory illness in children

**Respiratory symptoms and signs**
- Noisy Breathing
  - Wheeze
  - Grunting
  - Stridor
- Cough
- Breathlessness
  - Increased respiratory frequency
  - Increased work of breathing
- Chest pain
- Apnea or decreased respiratory frequency

**Non-respiratory signs & symptoms**
- Poor feeding
- Abdominal pain
- Poor color
- Change in mental state: drowsiness or agitation
- Poor tone: floppiness
- Meningism
Assessment of breathing in children

**Signs of increased effort (work) of breathing**
- Increased respiratory frequency
- Chest indrawing (recession)
- Accessory muscle use
- Alae nasi flaring
- Tracheal tug
- Stridor
- Wheezing
- Grunting or gasping

**Signs of decreased efficacy**
- Decreased chest expansion
- Decreased, absent or asymmetrical breath sounds
- Reduction in SaO$_2$ on room air
Signs and symptoms of respiratory distress

- Tachycardia

- Tachypnea – RR above 40 in an infant and above 30 in a child.

- Suprasternal retractions indicate more severe obstruction than intercostal and subcostal retractions.
WARNING SIGNS of impending respiratory failure
- marked retractions
- Decreased or absent breath sounds
- Increasing tachycardia
- Decreasing respiratory effort or rate,
- Decreasing stridor
- A worried or unsettled appearance.

Ominous signs
- Decreased Level of conc.
- Extreme pallor
- Head-bobbing with each breath
- Decreased Heart rate.
How can you tell where the problem is?

- Stridor, which is derived from Greek, meaning “creaking,” is caused by rapid turbulent flow through a narrowed airway.

- The sound generated depends on the degree of constriction and the localization of the obstruction.

- Observation of the child often offers the best clue to localization.
## Causes of acute stridor

<table>
<thead>
<tr>
<th>INCIDENCE</th>
<th>DIAGNOSIS</th>
<th>CLINICAL FEATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very common</td>
<td>Croup: viral laryngotracheitis</td>
<td>Fever, coryza, barking cough, hoarse, mild</td>
</tr>
<tr>
<td>Common</td>
<td>Croup: recurrent/spasmodic croup</td>
<td>Sudden onset, history of atopy</td>
</tr>
<tr>
<td>Uncommon</td>
<td>Laryngeal foreign body</td>
<td>Sudden onset, history of choking</td>
</tr>
<tr>
<td>Rare</td>
<td>Epiglottitis</td>
<td>Drooling, muffled voice, appears septic, unimmunized</td>
</tr>
<tr>
<td></td>
<td>Bacterial tracheitis</td>
<td>Harsh cough, chest pain, appears septic</td>
</tr>
<tr>
<td></td>
<td>Trauma</td>
<td>Neck swelling, crepitus or bruising</td>
</tr>
<tr>
<td></td>
<td>Retropharyngeal abscess</td>
<td>Drooling, appears septic</td>
</tr>
<tr>
<td></td>
<td>Infectious mononucleosis</td>
<td>Sore throat, tonsillar enlargement</td>
</tr>
<tr>
<td></td>
<td>Inhalation of hot gases</td>
<td>Facial burns, perioral soot</td>
</tr>
<tr>
<td></td>
<td>Angioneurotic edema</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Diphtheria</td>
<td>Travel to endemic area, unimmunized</td>
</tr>
</tbody>
</table>
How can you tell where the problem is?

- A child who assumes the “sniffing position” has significant upper airway obstruction, as does a child who is dysphagic or drools.

- **REMEMBER** – expiration should be passive and that active expiration with a prolonged expiratory time, recruitment of the accessory muscles, wheezing, and a “tripod” position is significant for severe lower airway obstruction.
Cyanosis is an extremely late sign in upper airway obstruction.

The clinical state of the child should dictate intervention, with the most important parameter being mental status.

A CHILD WHO DOES NOT CRY IS NOT BEING GOOD. THE CHILD IS IN BIG TROUBLE.
Summary

How can you tell where the problem is?

- Supraglottic lesions
  - inspiratory stridor, a prolonged inspiratory phase, and a muffled cry or voice.

- Glottic lesions also lead to high-pitched inspiratory stridor and a weak or hoarse voice.

- Subglottic lesions cause expiratory stridor with a normal voice and a brassy cough
General Treatment

- Airway, airway, airway
- Supplemental oxygen
- Position of comfort

REMEMBER – almost all children with an U.A.O. can be bag-valve-mask ventilated, and this should always be tried first in a respiratory failure situation.

- Advanced airway management, IV, cardiac monitor, Pulse ox, etc.
Always have a smaller ET tube readily available because of the possibility of significant airway edema.

Watch for aspiration
Remember……………

Failure to manage the airway is the leading cause of preventable deaths in children.
Introduction

- Upper airway obstruction accounts for ~ 15% of all pediatric emergency room critically ill patients.
- Infectious etiologies: 90%, with viral croup accounting for 80%.
- Epiglottitis accounts for 5% of severe cases.
- Other etiologies: bacterial tracheitis, tonsillar pathology, mononucleosis, and diphtheria.
- Traumatic etiologies: including foreign bodies, external trauma to the neck, burns, & iatrogenic (post intubation).
- Congenital etiologies must be considered in young infants.
- Less common causes: tumors & edema secondary to severe allergic reaction.
Causes of acute upper airway obstruction that are commonly life-threatening

- Epiglottitis
- Croup
- Retropharyngeal abscess
- Bacterial tracheitis
- Foreign body
- Anaphylaxis
- Neck trauma
- Burns (thermal or caustic)
- Acute on chronic conditions
What is the problem?

A 10 month-old boy awakens at midnight with noisy breathing and a barking cough. T: 38.3°C (101°F)
What caused the Problem?
What caused the Problem? Croup (laryngotracheitis)

- It is a respiratory illness characterized by inspiratory stridor, barking cough, and hoarseness.

- It typically occurs in children 3 months to 3 years of age.

- It is mainly caused by parainfluenza virus.

- It is the most common cause of infectious acute upper airway obstruction.
What caused the Problem? Croup (laryngotracheitis)

- Initial port of entry is the nose and Nasopharynx

- Begins with a Prodrome of a few days of mild URI with nasal congestion, sore throat and cough.

- As the infection spreads distally, so does the edema.

- A hoarse voice and harsh, brassy, bark like cough (barking like a seal)

- Stridor usually develops at night
Treatment of Croup

- Depend upon the severity of symptoms and the presence of risk factors for rapid progression.

- There is no definitive treatment for the viruses that cause croup.

- Pharmacologic therapy is directed toward decreasing airway edema and supportive care is directed toward the provision of respiratory support and the maintenance of hydration.
Croup occasionally results in significant UAO with impending respiratory failure, heralded by the following signs:

- Fatigue and listlessness
- Marked retractions
- Decreased or absent breath sounds
- Depressed level of consciousness
- Tachycardia out of proportion to fever
- Cyanosis or pallor
Treatment: moderate/Severe Croup

- Supportive care
  - Administration of humidified air/O$_2$
  - Provision of intravenous fluids
  - Monitoring for worsening respiratory distress.
Treatment: moderate/Severe Croup

- Nebulized epinephrine (Grade 1A) given over 15 minutes
  - Racemic epinephrine: 0.05 mL/kg per dose (maximum of 0.5 mL) of a 2.25% solution, repeat q15-20 min PRN

- Dexamethasone (Grade 1A)
  - 0.6 mg/kg, maximum of 10 mg, by the least invasive route
  - Nebulized budesonide 2 mg (can be mixed with epinephrine)

- Observe for three to four hours after intervention.

- If condition worsens or fails to improve → Admission

- Repeated doses of corticosteroids not helpful (Grade 2C)

- HeliOx: By ↓ gas density, airway resistance can be ↓ in the absence of any anatomical change
Croup: Discharge criteria

- After three to four hours of observation, children who remain comfortable may be discharged home if they meet the following criteria:
  - No stridor at rest
  - Normal pulse oximetry
  - Good air exchange
  - Normal color
  - Normal level of consciousness
  - Demonstrated ability to tolerate fluids by mouth
  - Caregivers understand the indications for return to care and would be able to return if necessary

- Follow-up with the primary care provider within the next 24 hours.
What caused the Problem?

- A 2-year-old boy has had a temperature of 38.9°C (103.2°F)
- Marked respiratory distress
- Inspiratory and expiratory stridor
- Barking cough. He has not been drooling
- A complete blood count reveals a leukocyte count of 18,800/mm³.
- The usual treatments for croup have been ineffective.
What caused the Problem?
What caused the Problem? Bacterial tracheitis

- Rare but serious cause of stridor and UAO in children.
- Peak incidence at about 3 - 4 yrs. of age.
- Usually a complication of a preexisting viral infection (concomitant viral respiratory cultures were positive in 72%)
- Severe inflammation of the tracheal epithelium $\Rightarrow$ sloughing of epithelium into the lumen.
- The predominant organisms: aerobic bacteria (43%), anaerobic bacteria (20%), and mixed anaerobic and aerobic flora (36%).
  - (S. aureus, H. influenzae type b, Moraxella catarrhalis, Peptostreptococcus species, Prevotella and Porphyromonas, and Fusobacterium species)
Bacterial tracheitis: Clinical Features

- Overlap the symptoms of both croup and epiglottitis
- Features that suggest **bacterial tracheitis** include:
  - A viral Prodrome followed by acute decompensation
  - Symptoms atypical for croup (high fever, cyanosis, and severe distress)
  - A poor response to usual treatment of croup (steroids and epinephrine)
  - The presence of both inspiratory and expiratory stridor.
Differentiating bacterial tracheitis from severe croup or epiglottitis on clinical grounds alone can be difficult.

- In a combined analysis of three studies, the correct initial diagnosis of bacterial tracheitis was made in only 4 of 26 patients. [1]
- In another report of 16 patients with bacterial tracheitis, an initial diagnosis of croup was made in 7 and acute epiglottitis in 2.[2]

Bacterial Tracheitis: Diagnostic Strategies

Evaluation of a toxic-appearing child with bacterial tracheitis should be conducted expeditiously.

- **Laboratory tests are nondiagnostic**
  - WBC is normal or slightly elevated.
  - Blood cultures are usually negative.

- **Lateral and anteroposterior views of the neck and chest may be helpful**.
  - Subglottic narrowing,
  - A ragged edge and a hazy density within the tracheal lumen.
  - The epiglottis and supraglottic structures appear normal.
  - The chest radiograph may reveal coexisting pneumonia.

- **Bronchoscopy** (is both diagnostic and therapeutic)
  - Visualization of the supraglottic structures and larynx
  - Exclusion of other pathology
  - Suctioning of tracheal secretions and debris
  - Establishment of an artificial airway
Bacterial tracheitis: Management

- In relatively few cases, severe distress requires immediate intubation and suctioning in the emergency department.
- Airway management in the setting of the operating room is preferred.
- These patients require hospital admission, intensive care, supplemental oxygen, fluid resuscitation, and broad-spectrum antibiotics.
An 18 month old female presented to the Emergency Department with a history of fever, noisy breathing, a harsh cough, and drooling.
Epiglottitis

Typical epiglottitis caused by *H. influenzae* type b

- The incidence has declined markedly over the last 15 years in developed countries after the widespread use of HiB vaccine.

- Still a common cause in developing countries – In Ethiopia only 24 percent of children age 12-23 months were fully vaccinated (based on data from The 2011 Ethiopia Demographic and Health Survey)

- Other organisms: A beta-hemolytic *Streptococcus*, *S. aureus*, and *Streptococcus pneumoniae* are more common.

- Noninfectious causes are rare and include thermal injury from swallowing hot liquids.
Epiglottitis

- Affects children between 3 and 7 years of age and occurs year-round.

- It is an invasive bacterial disease that causes inflammation and edema of the epiglottis, aryepiglottic folds, and surrounding supraglottic tissues.

- As these structures become inflamed and distended, they protrude downward and over the glottic opening.
Epiglottitis: Clinical Features

- Classically an acute condition, without an extended Prodrome.
- High fever, intense sore throat, toxicity, and rapid progression.
- Anxious appearance
- Maintain themselves in a ‘sniffing’ or ‘tripod’ position

- As symptoms worsen, cough and phonation are usually absent.
- Drooling is prominent because of an inability to swallow.
- Croup is the most commonly assigned misdiagnosis
Epiglottitis: Diagnostic Strategies

- Direct examination of the pharynx

  - Should be reserved for stable patients in whom the diagnosis is in doubt.

  - It should be performed only in a setting in which both the equipment and personnel required for emergency intubation are at hand.

  - Stimulation of the posterior of the pharynx with subsequent contraction of the pharyngeal muscles may increase airway obstruction.
Epiglottitis: Diagnostic Strategies

- A lateral neck radiograph
  - An enlarged epiglottis (‘thumbprint sign’)

- Careful observation of a child with suspected epiglottitis is essential.
The clinical features of classic epiglottitis are usually sufficiently characteristic that diagnostic tests are not necessary and should be avoided.

The importance of securing the airway takes precedence over diagnostic evaluation.

- A ‘stable’ patient who is maintaining a patent airway and adequate oxygenation should not be moved or repositioned for examination, laboratory tests, or radiography.
Careful decision making is essential when a child with **epiglottitis** requires transport. Expeditious controlled intubation remains optimal management.

Unstable patients with respiratory failure require assisted ventilation.

- Bag/mask ventilation should be attempted first and, if successful, continued until intubation can be performed.
- If neither bag/valve/mask ventilation nor intubation are successful, more aggressive techniques such as needle cricothyroidotomy or tracheostomy may be indicated.
18-month-old toddler with retropharyngeal abscess
A retropharyngeal abscess

- Is a potentially life-threatening airway emergency resulting from infection of the retropharyngeal soft tissue space.
  - The retropharyngeal space extends from the base of the skull to the level of T2.
  - It is rich in lymph tissue that drains the nose, pharynx, sinuses, and ears.
  - *Staphylococcus aureus*, group A *Streptococcus*, and anaerobes are the organisms most commonly responsible for this infection
A retropharyngeal abscess

- Common signs and symptoms include:
  - fever, sore throat, neck stiffness/nuchal rigidity, torticollis, trismus, neck swelling, drooling, stridor, and a muffled voice.

- Complications of a retropharyngeal abscess
  - generalized sepsis, aspiration pneumonia, mediastinitis, and empyema.
A retropharyngeal abscess

- A soft tissue lateral view of the neck may be helpful to evaluate the fullness of the retropharyngeal soft tissues.
  - The width of the retropharyngeal space should not exceed the diameter of the adjacent vertebral body.
  - An air-fluid level is more commonly seen with perforations and anaerobic infections.
  - CT may be beneficial in selected cases.

Management depend on

- The size of the abscess, the degree of airway obstruction, and the overall toxicity of the patient.
- The need for intubation or surgical drainage is determined on an individual basis.
- These patients generally benefit from involvement of an ear, nose, and throat specialist.
What caused the Problem?

- 15 mo. old girl with 4 months of cough and intermittent noisy breathing
- Admitted centrally cyanosed on one occasion, never ventilated
- Came to ER after “turning blue” at home.
- Poor response to therapy
- CXR, CT scan, bronchoscopy:
What physical exam sign/symptom is most suggestive of foreign body aspiration?

A. Fever
B. Polyphonic wheezing
C. Cough
D. Stridor
E. Monophonic wheezing
Foreign body aspiration (FBA)

- Most common in children 3 months to 6 years of age
- Male/Female: 1.7 / 1
- Vegetables or pieces of toys
- Normal CXR in up to 80% of children with laryngeotracheal FBs, and in 30-50% of children with bronchial FBs (Mu et al. J laryngol Otol 1990;104:778-82).
- Inspiratory/Expiratory films in older children
  - Positive in up to 77% of FB (Steen et al. Laryngoscope 1990; 100:525-30)
Which radiographic imaging study would be the most helpful if a foreign body aspiration is suspected in a child (<3 yr.)?

A. PA
B. Inhalation/Exhalation
C. Lateral
D. Decubitus
Decubitus films in foreign body aspiration

- The lung that is down should normally deflate, due to the weight of the mediastinum.

- If expiration is partially blocked, deflation will be less evident: (ball valve effect).

Decubitus films in younger, uncooperative subjects
What caused the Problem: Foreign Body

- Very sudden onset of symptoms

- Ask specifically about the possibility of choking or aspiration

- Listen for abnormal signs – asymmetric, fixed monophonic wheeze; Signs MAY be bilateral, or absent

- CXR may be normal

  - Bronchoscope on history alone
  - World Record – 25 years delay?
Where is the coin?
Esophagus vs. Trachea
## Symptoms and signs of foreign bodies in different locations

<table>
<thead>
<tr>
<th>Location</th>
<th>Signs and symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supraglottis</td>
<td>Cough, dyspnea, salivation, voice changes</td>
</tr>
<tr>
<td>Larynx</td>
<td>Stridor, cough, voice changes, severe difficulty breathing</td>
</tr>
<tr>
<td>Trachea (extra)</td>
<td>Inspiratory stridor, expiratory rhonchus</td>
</tr>
<tr>
<td>Trachea (intra)</td>
<td>Expiratory wheeze, inspiratory rhonchus</td>
</tr>
<tr>
<td>Bronchus</td>
<td>Cough, wheeze or other localized sounds, difficulty breathing</td>
</tr>
</tbody>
</table>
Case 1: N.J.
N.J 2 years- old ER visit

- Known asthmatic, on inhaled steroids and Salbutamol

- Salbutamol every 2 hours for 2 days

- Temp 38.2°C, pulse 140/min, RR 28/min, BP 110/70, Cap refill normal, saturation 92% on room air.
How do we judge severity?

1. Peakflow measurement (if age appropriate)
2. Serial lung function
3. Pulse oximetry
4. Clinical signs and symptoms scores
# Initial assessment of acute asthma in children

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe and life-threatening*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altered consciousness</td>
<td>No</td>
<td>No</td>
<td>Agitated Confused/drowsy</td>
</tr>
<tr>
<td>Oximetry (SaO2) on presentation</td>
<td>94%</td>
<td>94-90%</td>
<td>Less than 90%</td>
</tr>
<tr>
<td>Talks in</td>
<td>Sentences</td>
<td>Phrases</td>
<td>Words Unable to speak</td>
</tr>
<tr>
<td>Pulse rate</td>
<td>Less than 100 beats/min</td>
<td>100-200 beats/min</td>
<td>More than 200 beats/min</td>
</tr>
<tr>
<td>Central cyanosis</td>
<td>Absent</td>
<td>Absent</td>
<td>Likely to be present</td>
</tr>
<tr>
<td>Wheeze intensity</td>
<td>Variable</td>
<td>Moderate to loud</td>
<td>Often quiet</td>
</tr>
<tr>
<td>PEF**</td>
<td>More than 60% predicted or personal best</td>
<td>40-60% predicted or personal best</td>
<td>Less than 40% predicted or personal best Unable to perform</td>
</tr>
<tr>
<td>FEV&lt;sub&gt;1&lt;/sub&gt;</td>
<td>More than 60% predicted</td>
<td>40-60% predicted</td>
<td>Less than 40% predicted Unable to perform</td>
</tr>
</tbody>
</table>

*Any of these features indicates that the episode is severe. The absence of any feature does not exclude a severe attack.

**Children under 7 years old are unlikely to perform PEF or spirometry reliably during an acute episode. These tests are usually not used in the assessment of acute asthma in children.
Pulse oximetry

- Strong relation to morbidity and mortality
- Predicts hospital admission (after >1 hr of treatment)

Asthma score

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>1 POINT</th>
<th>2 POINTS</th>
<th>3 POINTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(breaths/min)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2–3 yr</td>
<td>≤34</td>
<td>35–39</td>
<td>≥40</td>
</tr>
<tr>
<td>4–5 yr</td>
<td>≤30</td>
<td>31–35</td>
<td>≥36</td>
</tr>
<tr>
<td>6–12 yr</td>
<td>≤26</td>
<td>27–30</td>
<td>≥31</td>
</tr>
<tr>
<td>&gt;12 yr</td>
<td>≤23</td>
<td>24–27</td>
<td>≥28</td>
</tr>
<tr>
<td>Oxygen saturation (%)</td>
<td>&gt;95 with room air</td>
<td>90–95 with room air</td>
<td>&lt;90 with room air or supplemental oxygen</td>
</tr>
<tr>
<td>Auscultation</td>
<td>Normal breathing or end-expiratory wheezing</td>
<td>Expiratory wheezing</td>
<td>Inspiratory and expiratory wheezing, diminished breath sounds, or both</td>
</tr>
<tr>
<td>Retractions</td>
<td>None or intercostal</td>
<td>Intercostal and substernal</td>
<td>Intercostal, substernal, and supraclavicular</td>
</tr>
<tr>
<td>Dyspnea</td>
<td>Speaks in sentences or coos and babbles</td>
<td>Speaks in partial sentences or utters short cries</td>
<td>Speaks in single words or short phrases or grunts</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SEVERITY OF ASTHMA</th>
<th>MILD</th>
<th>MODERATE</th>
<th>SEVERE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak expiratory flow rate</td>
<td>&gt;70</td>
<td>50–70</td>
<td>&lt;50</td>
</tr>
<tr>
<td>(% of predicted value)†</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asthma score</td>
<td>5–7</td>
<td>8–11</td>
<td>12–15</td>
</tr>
</tbody>
</table>

Pathophysiology – asthma exacerbation

- Smooth muscle contraction
- Inflammation
- Mucus plugging
Ventilation – perfusion mismatch

A. Conditions with low ventilation-perfusion ratio

- No ventilation, normal perfusion
- Hypoventilation, normal perfusion
Treatment goals

- Correction of significant hypoxemia
- Rapid reversal of airflow obstruction
- (Reduction of the likelihood of relapse)
Initial steps in treating Asthma Exacerbation

- Oxygen
- Short acting beta-2-agonists (SABA)
- Ipratropium bromide (anticholinergics)
- Corticosteroid
Correction of hypoxemia

- **Supplemental oxygen**
  - Oxygen helps to correct V/Q mismatch.
  - Oxygen can be provided via nasal cannula or face masks.
  - Nonrebreathing masks can deliver as much as 98% oxygen.
  - The goal of supplemental oxygen therapy is an oxygen saturation above 90%.

- **Rarely mechanical ventilation (avoid if possible, try non-invaive Ventilation first)**
Short acting beta-2-agonists (SABA)

- Albuterol or salbutamol, and terbutaline, are the mainstays of acute therapy in asthma.

  - beta-receptors stimulation relaxes airway smooth muscles, increases Mucociliary clearance, and decreases mucous production.

- The nebulized inhaled route of administration is generally the most effective route of delivery.

- Some patients with severe refractory status asthmaticus may benefit by the addition of beta-agonists delivered intravenously.
Anticholinergics

- act via inhibition of cyclic guanosine monophosphate (GMP)–mediated bronchoconstriction.
- Less bronchodilation than β-2
- Effect is slower than β-2
- Decrease secretions
- Additive effect in acute phase

Rodrigo, Thorax 2005; 60:740-6
Corticosteroids

- Essential in treating inflammation
- Potentiate effect of SABA
- Improve capillary leaks
- Start working after 6-8 hours
- Dose 1-2 mg/kg/day in 1-2 doses

Smith, Cochrane Database Syst Rev. 2003;(2):CD002886
Result of therapy

- No relieve of dyspnea
- Pulse 160/min

So what’s next?
Result of therapy

- No relieve of dyspnea
- Pulse 160/min

- So what’s next?
Magnesium sulfate

- Works through additive bronchodilation (competing with calcium at calcium-mediated smooth muscle binding sites)
- Also pulmonary vasodilation
- Dose 25-100 mcg/kg, max 2 g in 10 minutes
- Inhaled MgSO₄

**MgSO₄ positive effect**
- J Pediatr 1996; 129:809-14

**MgSO₄ no effect**
Intravenous β-2 agonists

- **Continuous**
  - Starting dose 0.1 mcg/kg/min
  - Increase per 10 minutes
  - Max dose: 4 mcg/kg/min?
- **Bolus**
  - Single bolus salbutamol 15 mcg/kg is an option

D. Bohn, Crit Care Med. 1984;12:892-6

Browne, Lancet 1997; 349:301-5
Our patient...

- Still severely dyspnoic.
- Lab results:
  - $K^+ 2.8 \text{ mMol/L}$,
  - Lactate $4.0 \text{ mMol/L}$
  - Glucose $12 \text{ mMol/L} (= \text{ high})$
Adjunctive therapies

- Methylxanthines
- Heliox
- Mucolytics
- DNA-se
- Epinephrine
- Sodium bicarbonate

- Sedation
- Ketamine
- Fluids
- Bronchoscopy
- Anaesthetics
- NO
- ECMO
Methylxanthines

- Less role since the advent of potent selective β-agonists
- Weaker bronchodilators than SABA, but more adverse effects.
- Have no additional benefit to SABA + steroids

But

- In refractory status asthmaticus, shown to improve clinical asthma scores when compared with placebo control.
- Significantly lower costs associated with Theophyllin use.
- Other effects (diaphragmatic function, and central stimulation of breathing).

Epinephrine

- Historically: first line asthma treatment
- Nebulization: effect = albuterol, more SE
- Individual patients may react better
- Anaphylactic reaction => iv/im
Adjunctive therapies

- Methylxanthines
- Heliox
- Mucolytics
- DNA-se
- Epinephrine
- Sodium bicarbonate

- Sedation
- Ketamine
- Fluids
- Bronchoscopy
- Anaesthetics
- NO
- ECMO
The cause of acquired upper airway obstruction in children can often be identified by history and physical examination.

The greatest difference from adults that complicates upper airway obstruction in children does not relate to anatomical differences but to the speed with which respiratory failure can develop.

Airway protection may take precedence over any other therapeutic or diagnostic procedure.
PRACTICE POINTS

- Corticosteroids seem to bring about clinical improvement in children with viral croup within 6 hours and are equally effective if given orally, intramuscularly or by inhalation.

- Aerosolised alpha-sympathomimetics, such as adrenaline or racemic epinephrine, should be given a trial in acute severe upper airway obstruction.

- A normal chest x-ray does not rule out a foreign-body aspiration.