Respiratory Distress in the Pediatric Patient

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Pediatric Critical Care

Objectives

1

Discuss the unique characteristics of the pediatric airway

2

Learn how to assess a pediatric patient in respiratory distress

3

Review evaluation and management of specific respiratory pathologies

- Upper airway
- Lower airway
- Parenchymal lung disease

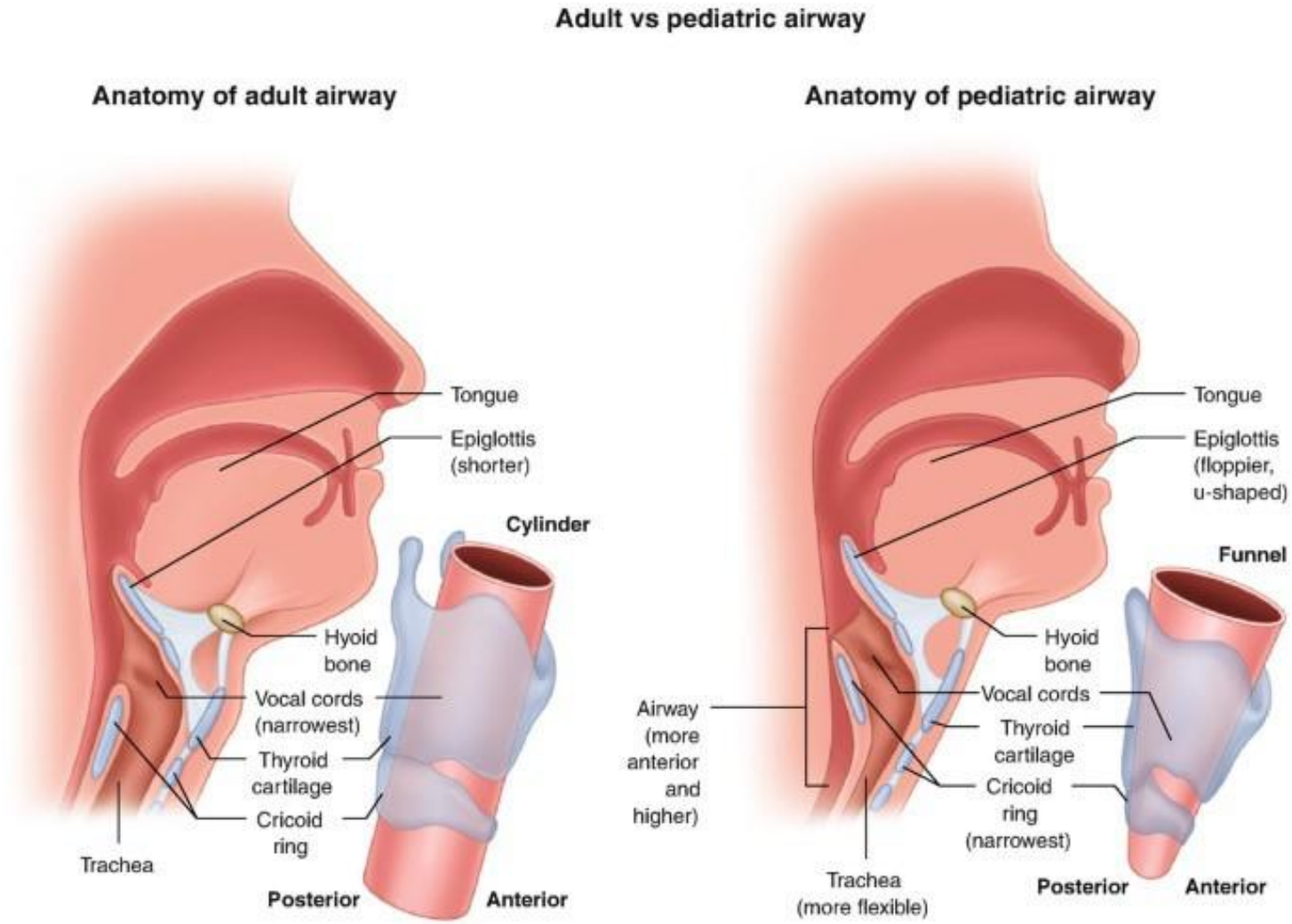
Anatomic Differences

- Craniofacial
  - Obligate nasal breathers
    - Neonates < 2 months
    - Up to age 1 rely heavily on nasal breathing
  - Large tongue in relation to oral cavity
  - Large occiput

Malhotra SK, Anaesth Pain, 2018

Anatomic Differences

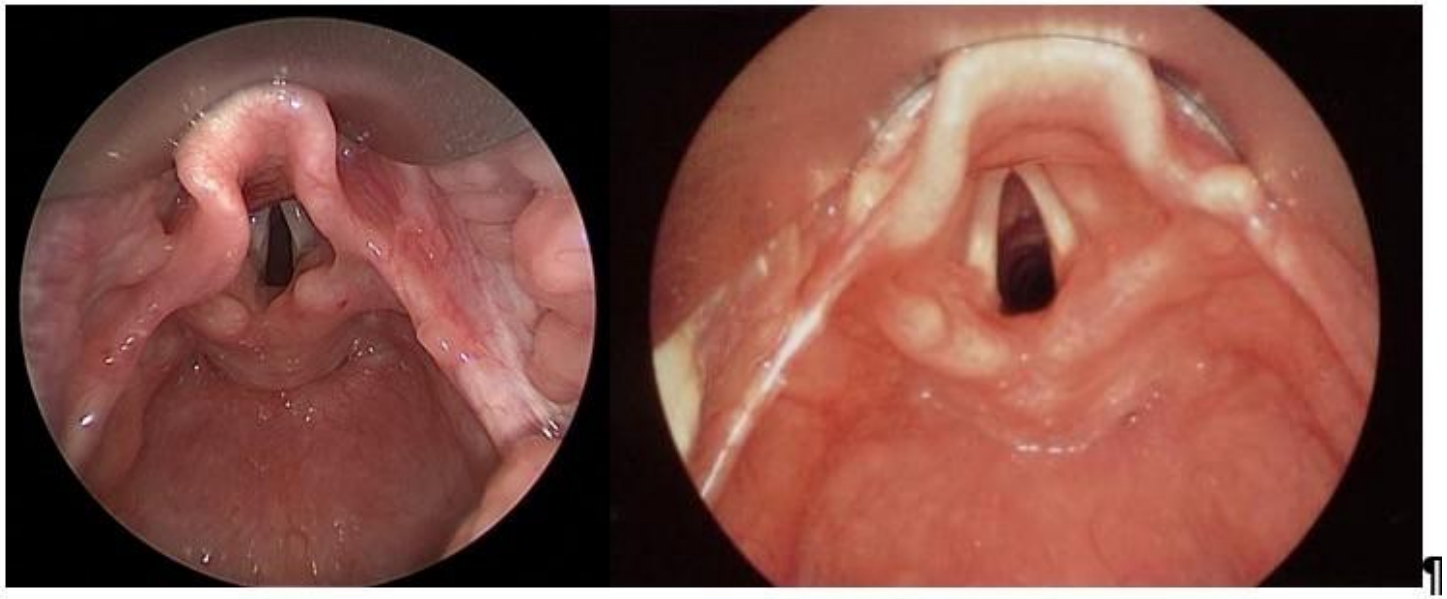
- Larynx
  - Higher in pediatrics
    - C2 in neonates
    - C3-4 in children
    - C5-6 in adults
  - Funnel shaped: narrowest portion in subglottic space



Zeretzke-Bien, Quick Hits for Ped, 2018

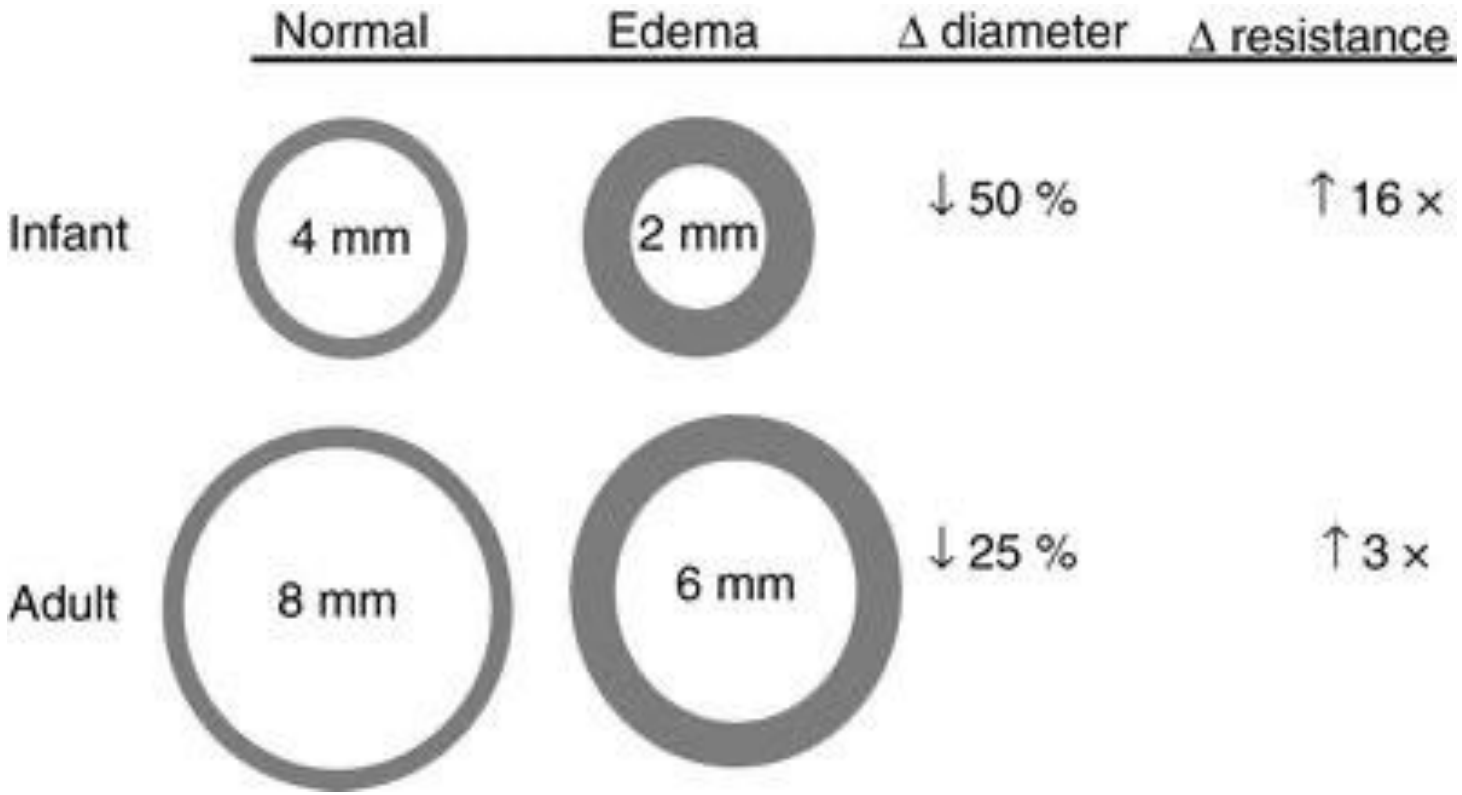
Anatomic Differences

- Epiglottis
  - Long, soft, omega shaped
  - Adult: shorter, rigid, flatter
  - Difficult to control during intubation



Anatomic Differences

- Trachea
  - Internal diameter is 1/3 of adult
    - $R=8nl/[pi]r^4$
  - Short length creates issues with inadvertent extubations
    - Newborn: 5cm
    - 18month: 7cm

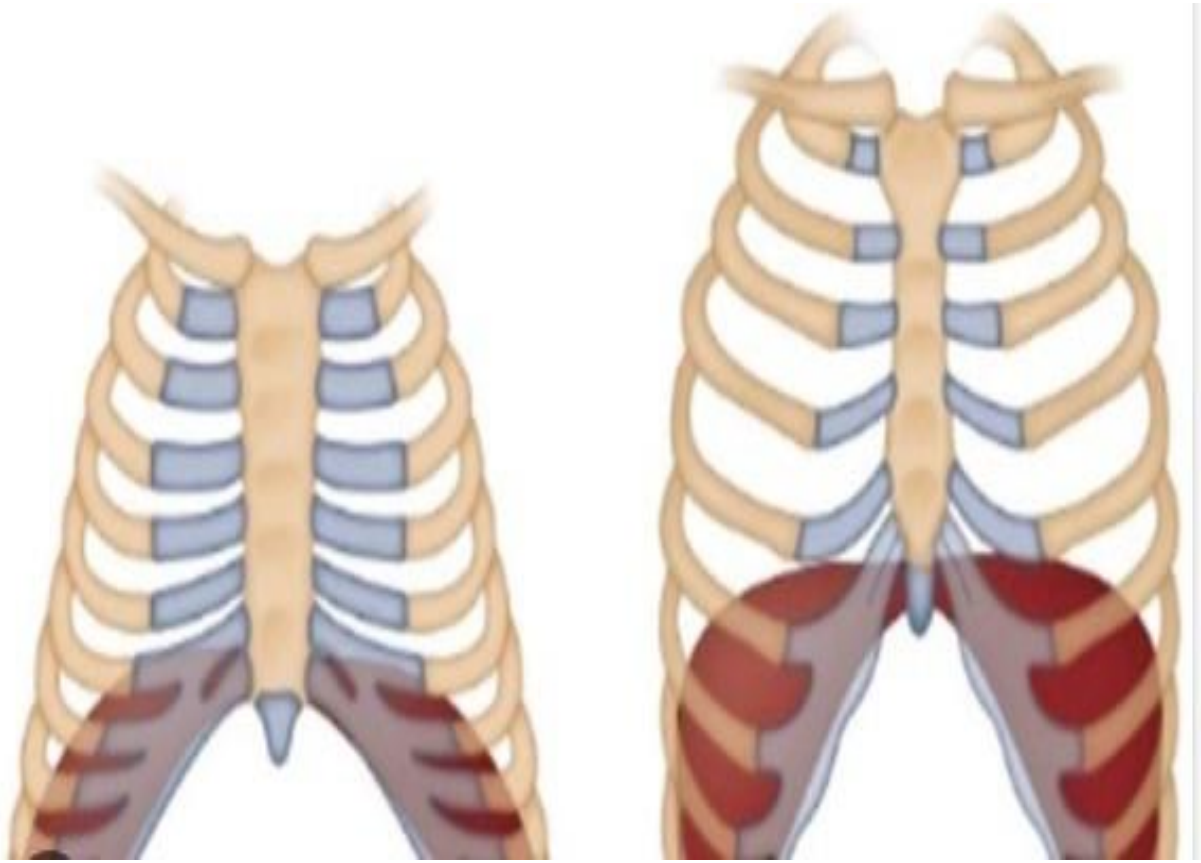


Wheeler et al., Resuscitation and Stabilization of the Critically Ill Child). Springer, 2009

Anatomic Differences

- Chest Wall
  - More cartilaginous-greater compliance
  - Ribs are positioned more horizontally [vs vertically] limits ability to increase TV
  - Thin chest wall
  - Diaphragmatic breathing in infancy
  - Fewer Type 1 fibers in respiratory muscles

- Pulmonary architecture
  - Fewer alveoli



Assessment of Respiratory State

- General Appearance
  - Muscle tone and movement
  - Interaction with providers and caregiver
  - Ability to cry or speak
  - Injury that may affect airway
  - Facial congenital abnormalities
  - Position of comfort
    - Tripoding?

Ledoux, M., *Pediatric Emergency Medicine Reports*, 2012

Assessment of Respiratory State

- Pulse oximetry
  - Continuous non-invasive measurement of arterial oxyhemoglobin saturation
  - Normal value?
    - We tolerate >92% to wean
    - We tolerate dips to 88% as long as self recovering
  - Special Circumstances
    - Requires pulsatile flow
    - Unreliable in carbon monoxide poisoning and methemoglobinemia
    - Nail polish colors can falsely lower readings

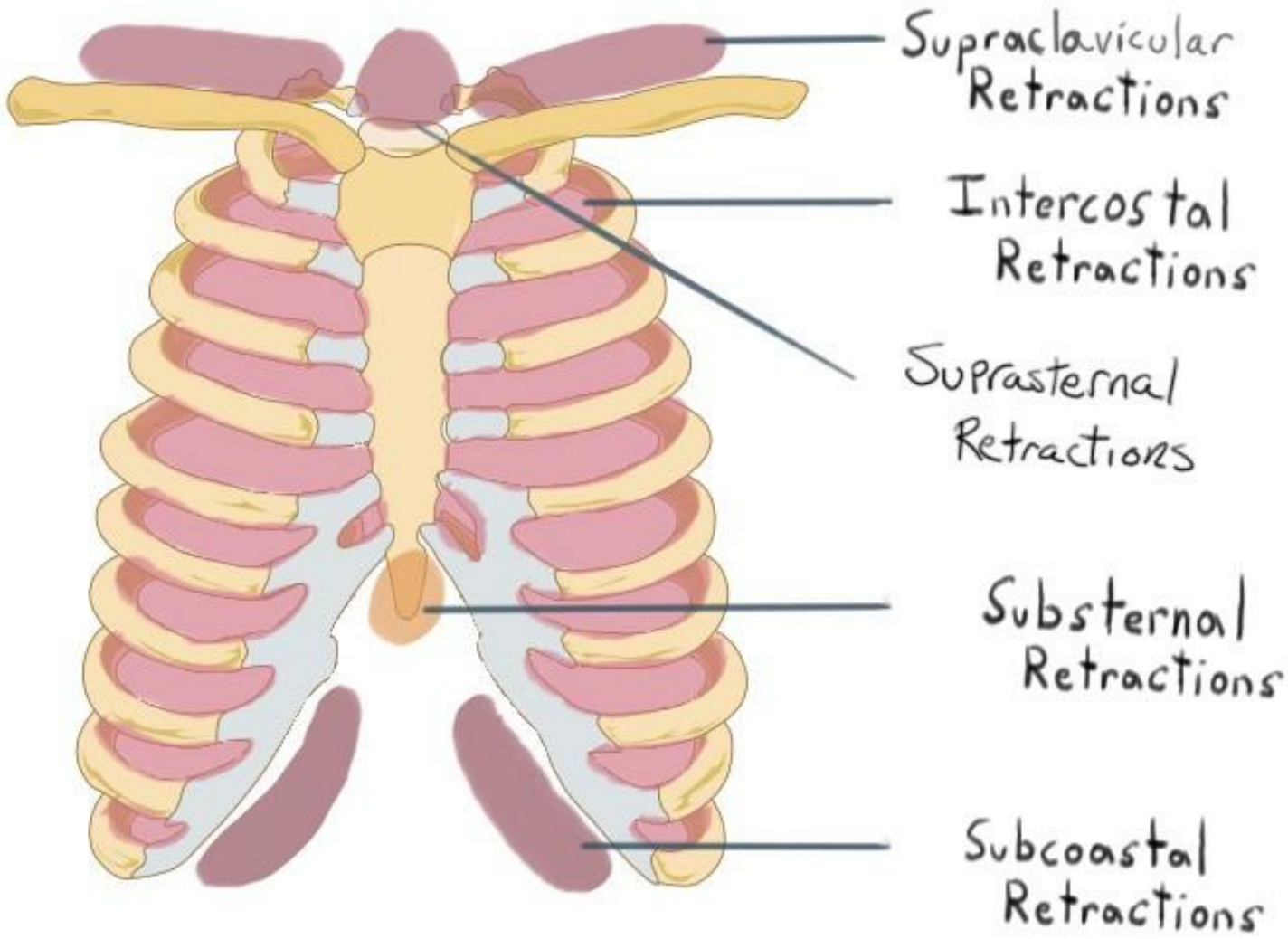
Assessment of Respiratory State

- Respiratory Rate
  - Expose chest and assess by observation

Age	Rate [breaths/min]
Infant	30-53
Toddler	22-37
Preschool	20-28
School-age	18-25
Adolescent	12-20

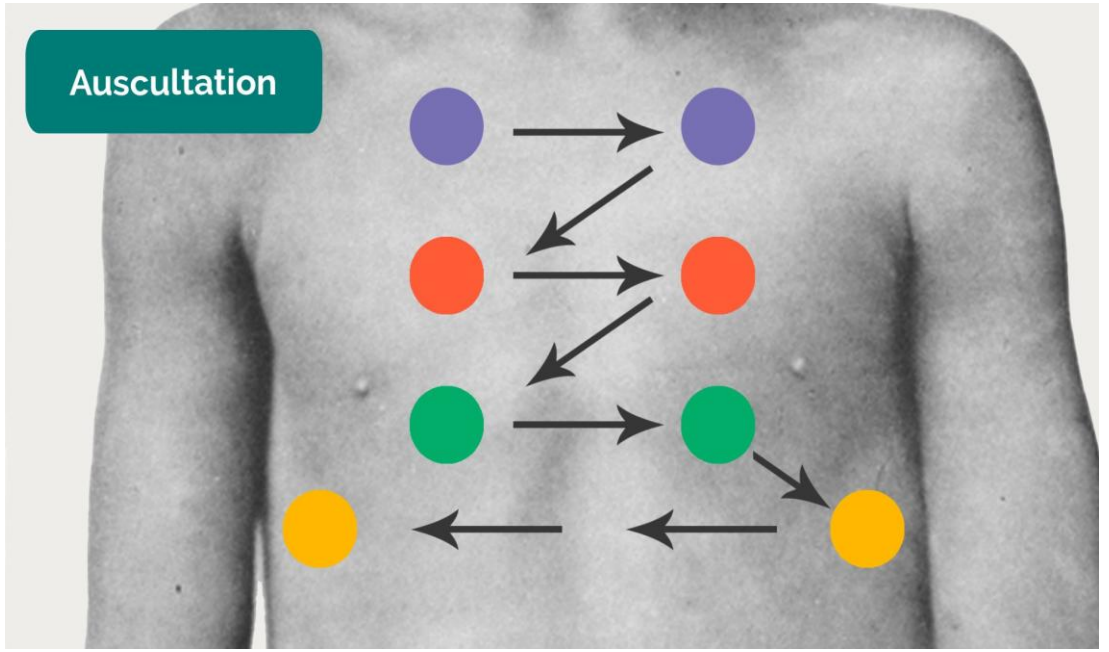
Assessment of Respiratory State

- Work of Breathing/Retractions
  - Nasal flaring-why?
  - Supraclavicular, intercostal, suprasternal, substernal retractions
  - Subcostal retractions [“belly breathing”]



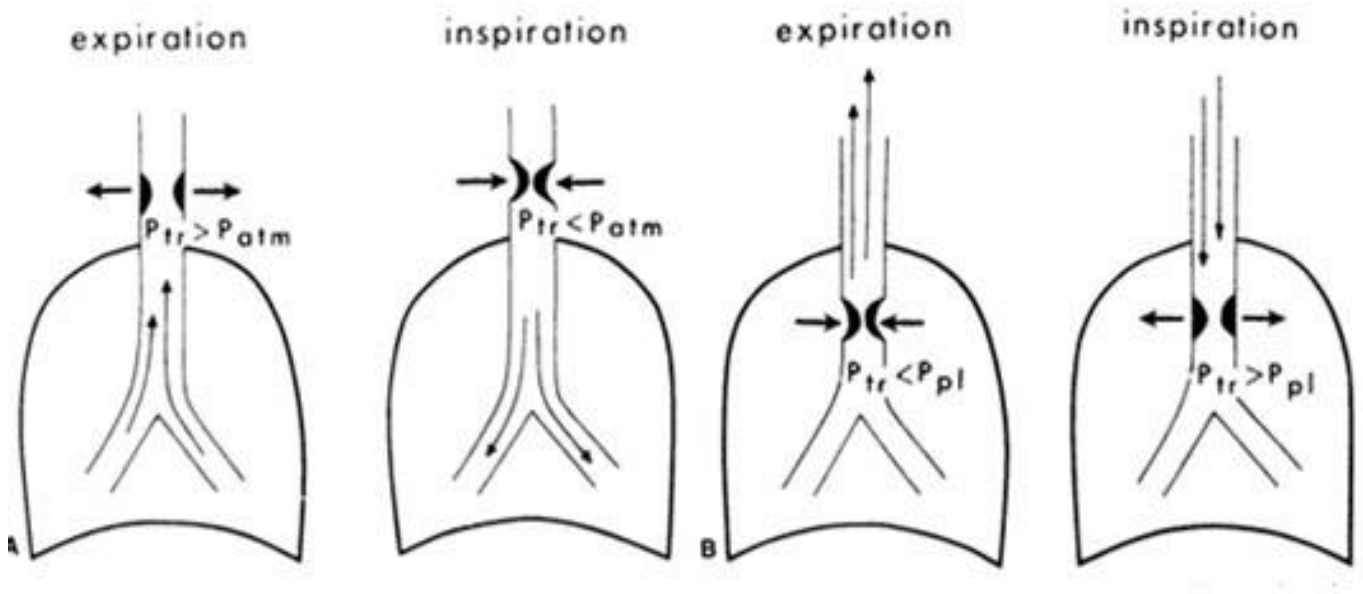
https://www.youtube.com/shorts/6Mmktf_pMKk?feature=share

Respiratory Assessment



- Auscultation
  - How
    - Over mouth, nose, neck, central and peripheral chest
    - Quality, pitch, asymmetry and magnitude
  - Sounds
    - Stertor: Inspiratory noise that emanates from the nose or pharynx, incomplete obstruction due to soft tissue collapse
    - Grunting: expiratory sound in an effort to prevent airway collapse by generating end expiratory pressure
    - Stridor: high pitched inspiratory sound
    - Wheezing: high pitched expiratory sound
    - Crackles: End inspiratory sounds usually heard with parenchymal lung disease
    - Asymmetry of breath sounds with…
    - Absence of breath sounds: complete airway obstruction

Respiratory Assessment



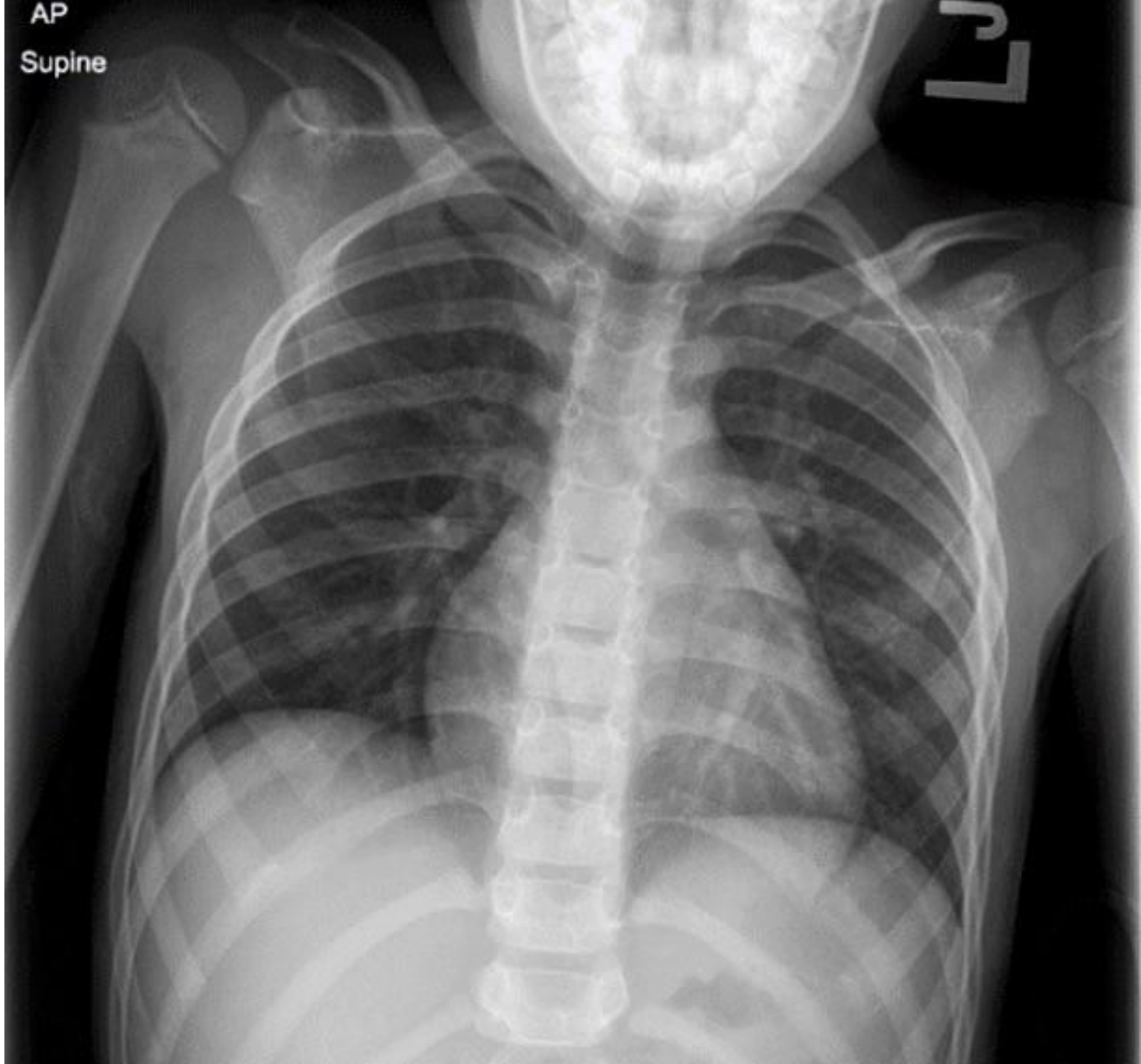
AIRWAY sounds are dictated by pressure exposure

- Inspiratory noise:
  - Airway disorder from nose to subglottic extra thoracic space
  - Extra thoracic trachea prone collapse with inspiration=stridor
    - Due to the negative inspiratory force created by inhaling against obstructed upper airway
- Expiratory noise
  - Airway disorder extends to intrathoracic airways of the chest
  - Intrathoracic airways prone to collapse with expiration=wheezing
    - Bronchi are connected to surrounding lung parenchyma which keeps airways open during inhalation due to negative pleural pressure

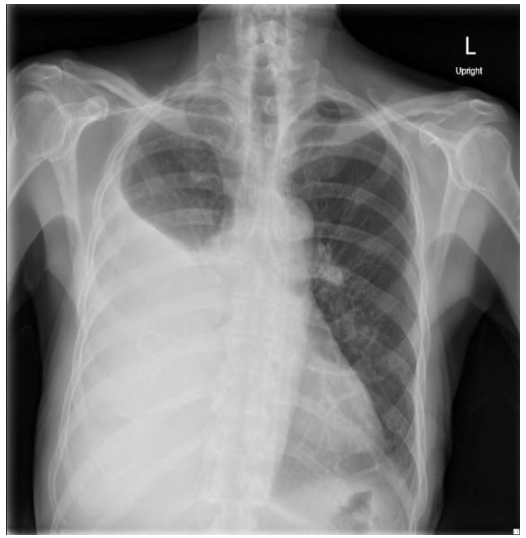
"What Determines the Major Lung Volumes?"

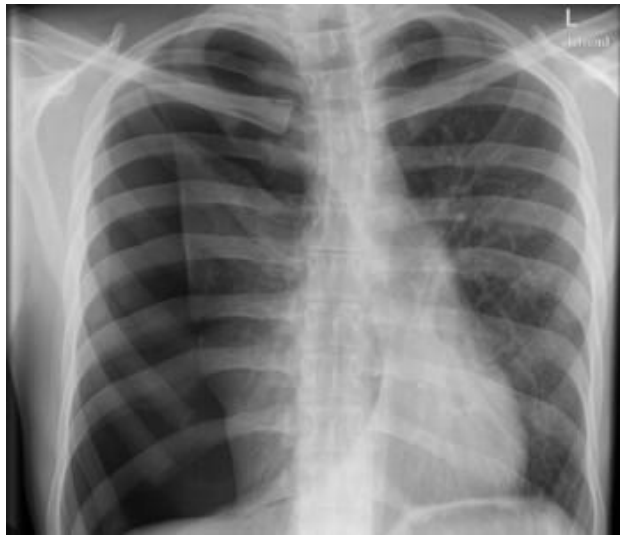
Respiratory Assessment

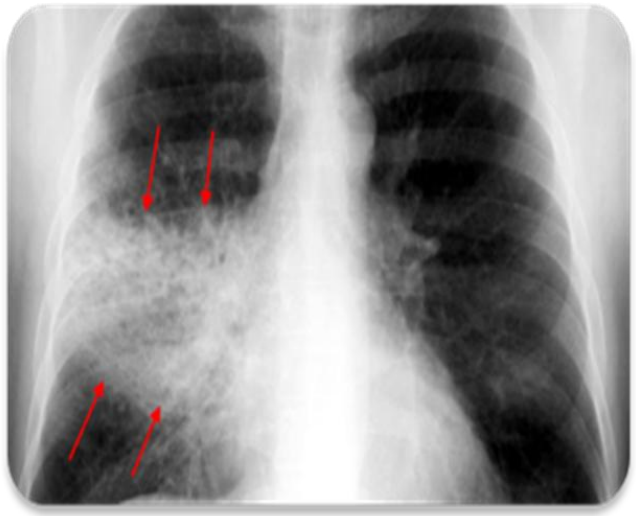
How do we read CXR’s?

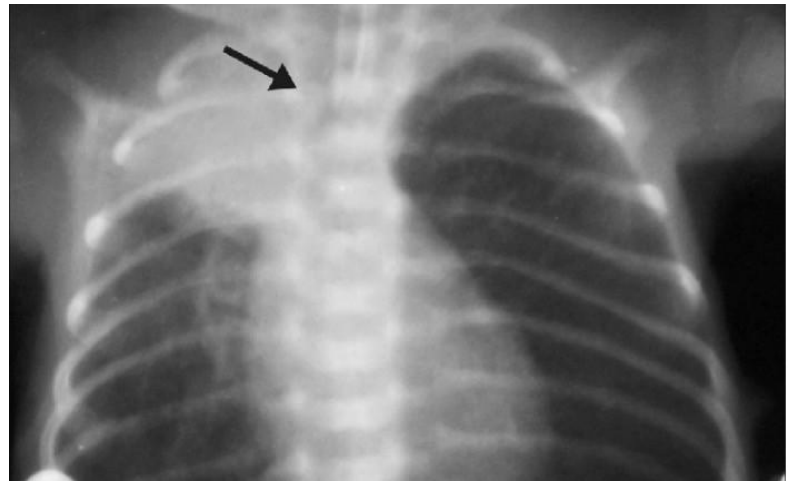


CXR Interpretation









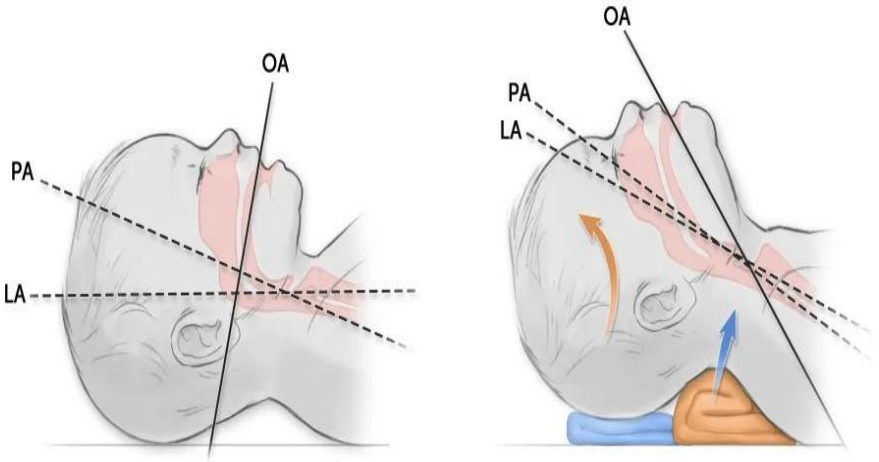
Respiratory Monitoring

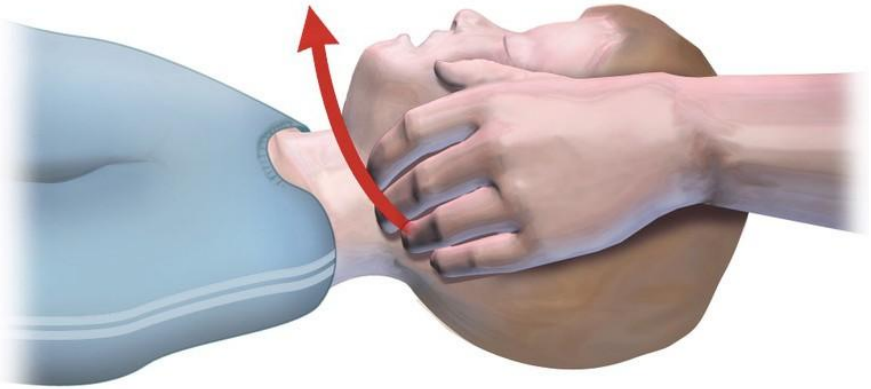
- Serial clinical assessments
- Pulse oximetry
- End-Tidal CO2
    - Estimates arterial CO2
    - Via nasal cannula or through ETT
- Arterial / Venous Blood Gas
    - pH/PCO2/PO2/HCO3
    - Normal values?

Respiratory Management

But first….opening a child's airway

- Goal: Align the oral, pharyngeal, and tracheal axes
- Problem:
  - Large head to body ratio leads to slight neck flexion in supine position
    - Small roll under shoulders
    - Avoid overextension
  - Pharyngeal soft tissue collapse or posterior movement of the tongue
    - Jaw thrust: fingers placed along posterior rami of mandible and mandible lifted upward and forward





"Tracheal Intubation"

Oxygen Delivery Devices

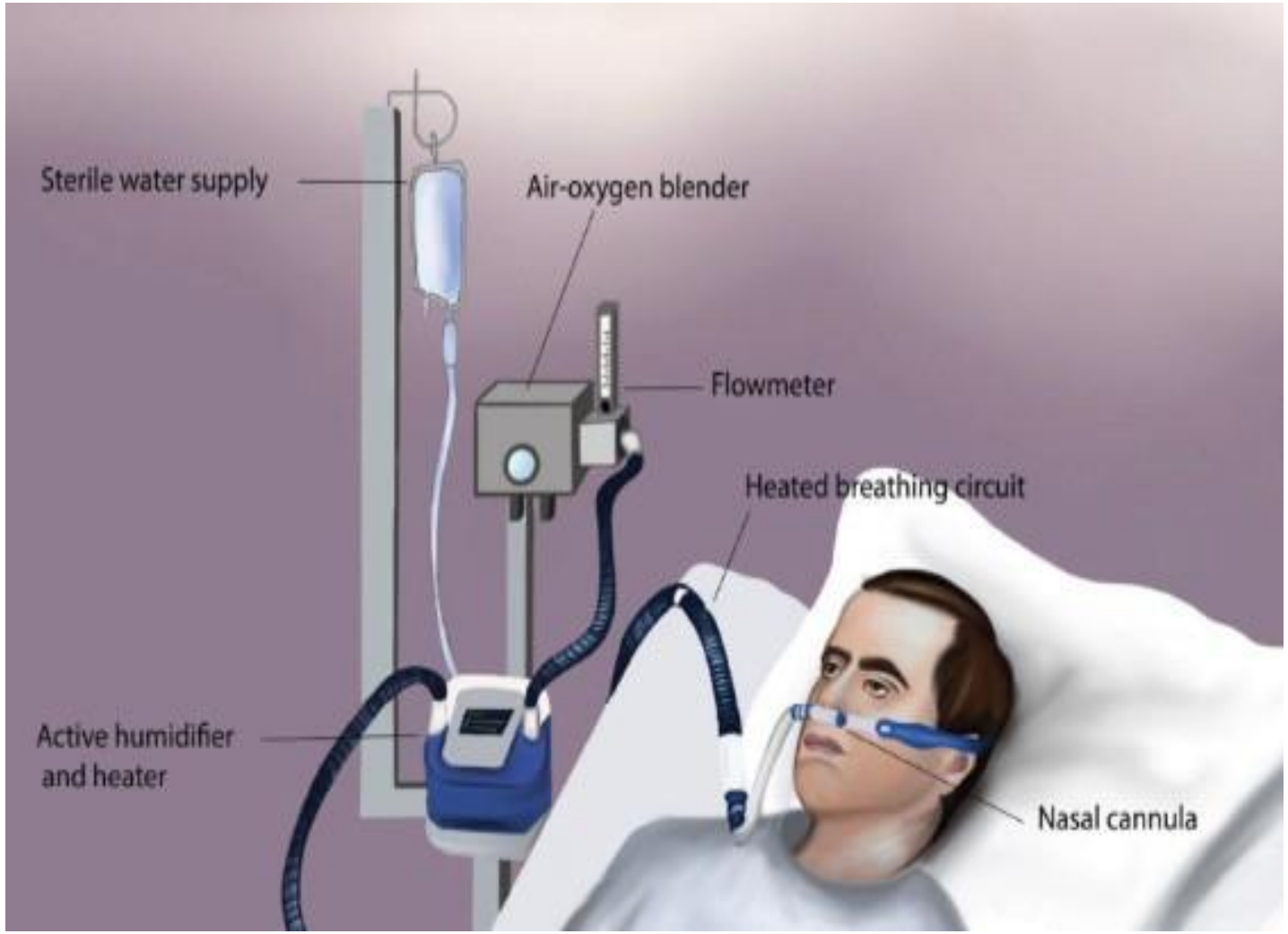
- Nasal Cannula
  - Low flow device
  - Max flow rate
  - FiO2 incremental rise

Oxygen Delivery Devices

- Non-Rebreather Mask
  - Face mask with reservoir bag
  - One-way valve on exhalation ports to prevent entrainment of RA
  - In inspiration, patient breathes in gas from reservoir bag
  - Delivers higher FiO2
  - Higher oxygen flow rate required

Oxygen Delivery Devices

- High-Flow Nasal Cannula
  - Flow rate 2-40L/min [weight based]
  - Decreased dead space ventilation
  - Heated, humidified gas
  - Titratable FiO2: 21%-100%
  - Degree of positive pressure



Al-Husinat L, *Journal of Clinical Medicine*. 2023

Oxygen Delivery Devices

- Bag Mask Ventilation
  - For inadequate spontaneous ventilation / apnea
    - Head positioning is key
    - Hand position
      - Non-dominant hand: E-Z clamp technique- thumb and forefinger form C shape on mas while remaining fingers form an E at mandible
      - Dominant hand: Compress bag and watch for chest rise
    - Two person bag-mask in difficult airways, time with respiratory effort
    - What do we assess?
    - Compressive force-avoid excessive volumes, why?
      - If pressure gauge available: avoid >30

Etiologies of Pediatric Respiratory Distress

- Upper airway obstruction
- Lower airway obstruction
- Disordered work of breathing
- Lung tissue disease

Upper airway obstruction

- Croup
- Anaphylaxis [angioedema]
- Foreign body obstruction
- Retropharyngeal abscess
- Bacterial tracheitis
- Epiglottitis

Lower airway obstruction

- Asthma
- Bronchiolitis

Disordered work of breathing

- Elevated ICP
- Neuromuscular
- Altered level of consciousness

Lung tissue disease

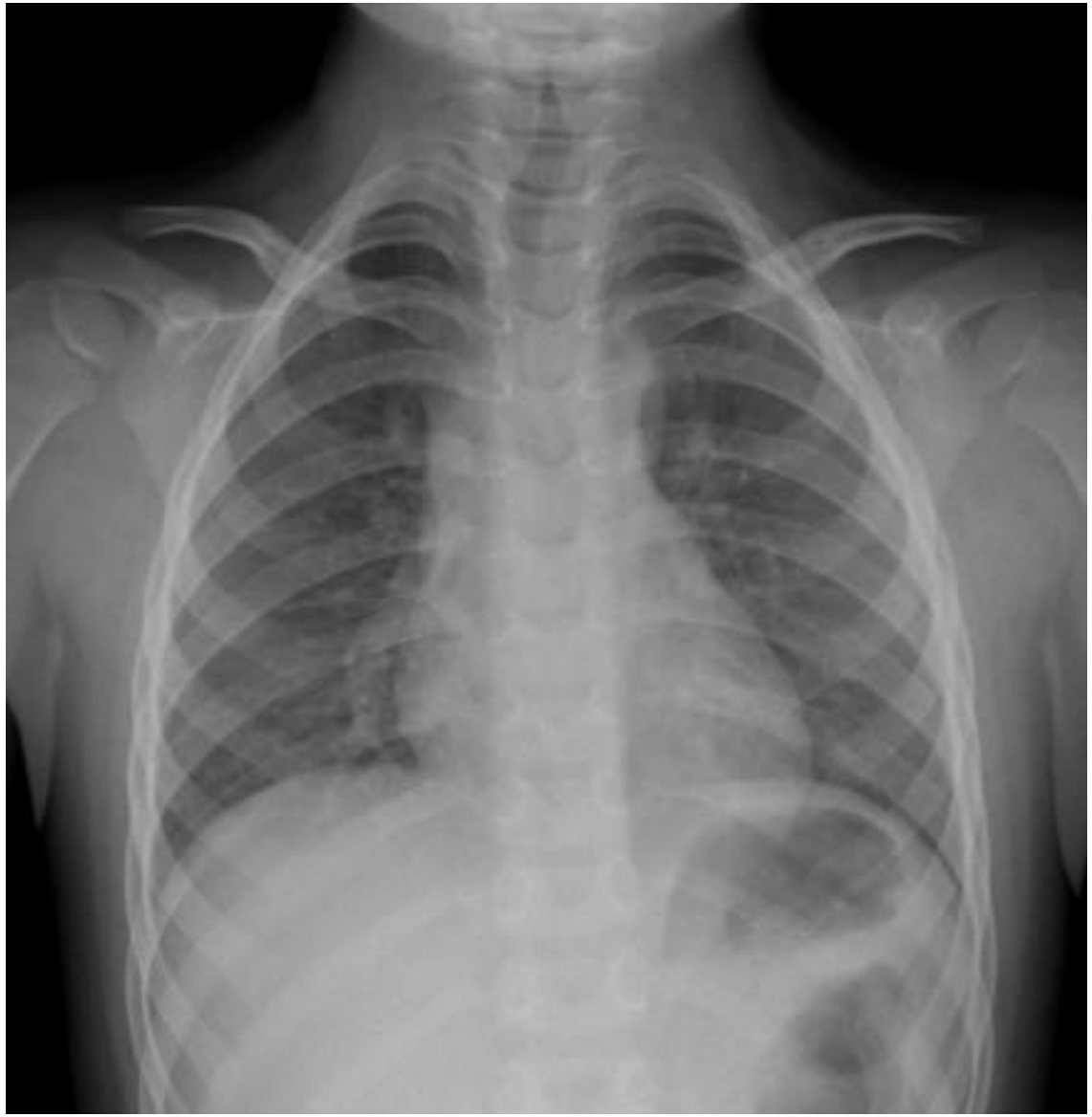
- Pulmonary Edema
- PNA

Disordered Work of Breathing

- Altered level of consciousness
  - Concern for ingestion
    - Think about giving…
  - Airway muscle laxity
    - What would you do first…
  - Hypopnea
    - The ultimate management…

Case Study

- 6month old boy presents to ED with fever, cough, rhinorrhea and difficulty/noisy breathing. On approaching the patient, you see deep subcostal retractions. When you auscultate you hear…
- VS: T101, RR 48, HR 130, SPO2 94%



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Croup [Laryngotracheobronchitis]

- **Pathophysiology**
  - Larynx and subglottic airway edema
    Cricoid cartilage of subglottic space is complete cartilaginous ring
  - Most common infectious cause of upper airway obstruction in children
- **Epidemiology**
  - Age: 6months-4years
  - Seasonal: Late fall-winter
- **Etiology**: Parainfluenza, H. influenzae, RSV, Adenovirus, M. pneumoniae
- **Clinical Manifestations**
  - Prodrome of rhinorrhea, low-grade fever, hoarseness, barky cough
  - Tachypnea, retractions, inspiratory stridor that worsens with agitation, prefer to sit

Croup [Laryngotracheobronchitis]

- **Diagnosis**: Clinical
  - AP/lateral neck film
  - Respiratory viral panel
  - Assessing severity: Westley croup score

TABLE 2

Westley Croup Score

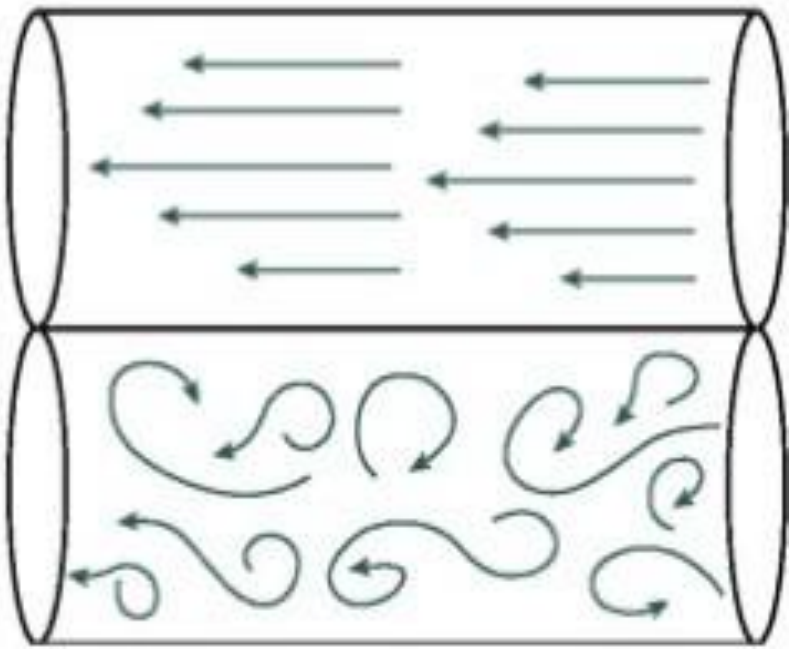
Clinical sign	Score
Level of consciousness	
Normal (including sleep)	0
Disoriented	5
Cyanosis	
None	0
With agitation	4
At rest	5
Stridor	
None	0
When agitated	1
At rest	2
Air entry	
Normal	0
Decreased	1
Markedly decreased	2
Retractions	
None	0
Mild	1
Moderate	2
Severe	3
Total score	**Croup severity**
≤ 2	Mild
3 to 7	Moderate
8 to 11	Severe
≥ 12	Impending respiratory failure

Adapted with permission from Westley CR, Cotton EK, Brooks JG. Nebulized racemic epinephrine by IPPB for the treatment of croup: a double-blind study. Am J Dis Child. *1978;132(5):485.*

Smith,DK, Am Fam Physician. 2018

Croup [Laryngotracheobronchitis]

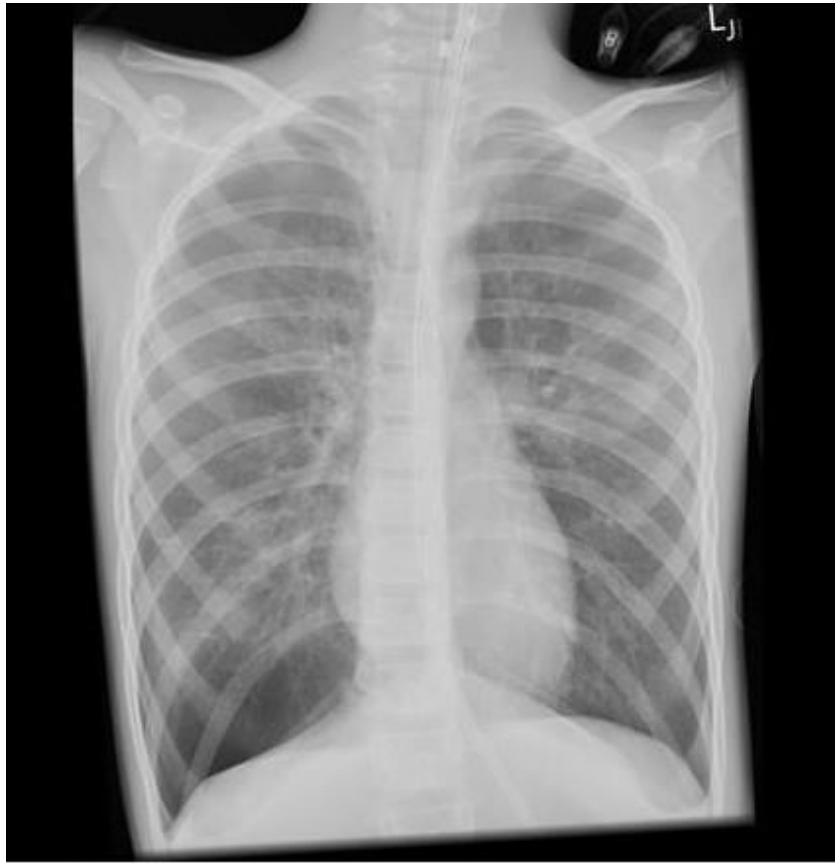
- **Treatment:**
  - Supportive care: minimize distress, blow-by oxygen, hydration
  - Symptom management:
    - Nebulized racemic epinephrine: 2.25%-0.5mL
    - Steroids [Oral, IM, IV]
      - Dexamethasone 0.6mg/kg [max 16mg]
    - Heliox
      - Helium and oxygen
      - Lighter gas
      - 60/40, 70/30, 80/20 concentrations



Herman, J.B, *Annals of the American Thoracic Society, 2017*

Case Study

- A 5y.o.F is borough to the ED for worsening tachypnea. The patient appears anxious as you approach her. On auscultation you hear this…
- VS: HR 135 RR 40 89% RA
- What is your diagnosis



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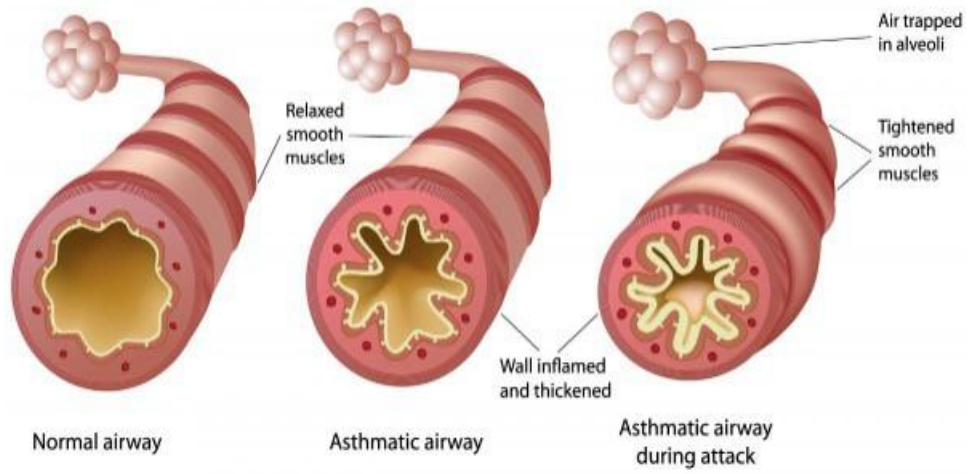
Asthma

- **Pathophysiology:** Chronic inflammatory lung disorder marked by recurring episodes of airway obstruction
    - Bronchospasm
    - Mucosal edema
    - Mucous plugging
- **Epidemiology:**
    - Most common chronic disease of childhood
- **Triggers:**
    - Viral infections
    - Weather change
    - Allergen / irritant exposure
    - Exercise
    - Reflux



"Asthma Pathophysiology " 2019

Asthma

- **Historical Information**
  - Frequency of symptoms: cough, wheezing, chest tightness, SOB
    - Nighttime symptoms
    - Interference with daily activity
  - Inhaler use
  - Precipitating factors
  - History of atopy or seasonal allergies
  - History of ED visits, PICU admissions, intubations, steroid courses
  - Family history

- **Clinical Manifestations**
  - Non-productive cough [initially], dyspnea, wheezing, increased WOB, prolonged expiratory phase

Asthma

- **Diagnosis**
  - Clinical
  - Further evaluation
    - CXR: If first time wheezing, concern for infectious bacterial process,
    - CBC
      - Leukocytosis
    - Electrolytes
      - Potassium? Magnesium?
    - Respiratory viral panel
    - Respiratory Distress Score [RDS}

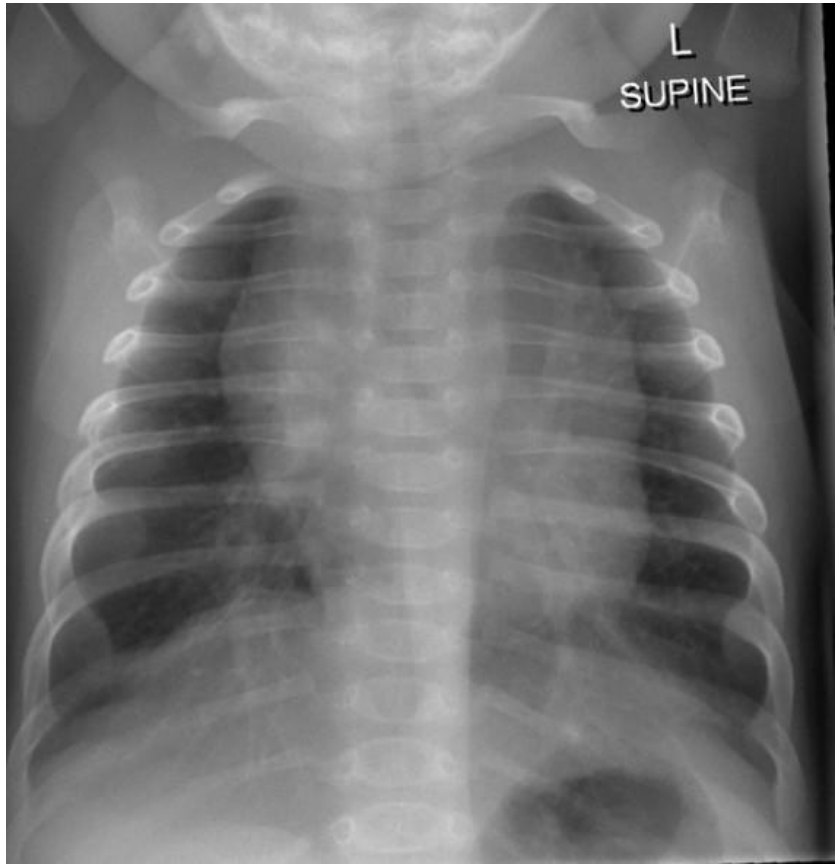
System	0	1	2	Score
Accessory muscle use	Absent or mild retractions	Moderate retractions	Severe retractions, nasal flaring	
Auscultation	No wheezing or end-expiratory wheezing only	Expiratory wheeze throughout	Inspiratory and expiratory wheeze or breath sounds becoming inaudible	
O2 saturation on RA	Greater than or equal to 95%	93%-94%	<93% on RA or on oxygen	
Resting RR *Less than 1y* *1-4 years old* *>4 years old*	 <40 <30 <24	 40-60 30-45 24-35	 >60 >45 >36	
Observation of distress	Minimal: playful, smiling, takes PO fluids well, can speak in full sentences	Moderate: takes PO fluids poorly, prefers sitting, short of breath while walking across room	Severe: unable to take PO, appears tired, unable to lie down, unable to say words	

Asthma

- **Treatment**
  - First line therapies
    - Inhaled B-agonist: Direct bronchial smooth muscle relaxation
      - Albuterol 0.5mg/kg; max 20mg
    - Inhaled Anticholinergics: Bronchodilation
      - Ipratropium 500mcg
    - Corticosteroids: Suppress components of inflammatory process
      - Methylprednisolone: Loading dose 2mg/kg followed by 1mg/g BID
  - Further therapies
    - Magnesium sulfate: CCB which inhibits smooth muscle contraction leading
      - 50mg/kg Q6H x 4doses
    - Intravenous B-agonists: Relative B2-agnosit
      - Terbutaline infusion

Case Study

- One month old M, previously 34WGA presents to ED with 1 week of rhinorrhea and cough. Over the past 12H, patient began grunting along with nasal flaring and subcostal retractions. He has been less active, feeding poorly, and Mom is concerned as infant stops breathing intermittently. On auscultation you hear…
- VS: t 100.6, RR 68, HR 165, SPO2 92%
- What is your diagnosis?



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Bronchiolitis

- **Pathophysiology**

  Acute inflammation of the lower respiratory tract resulting in obstruction of small airways with associated copious respiratory tract secretions

- **Etiology**

  RSV, HMPV, RE, Coronavirus, Adenovirus, Influenzae, Parainfluenza

- **Epidemiology**

  Typically <2y, peak 2-8months

- **Severe Disease Disk**

  Prematurity, congenital heart lesions, BPD, immunosuppression

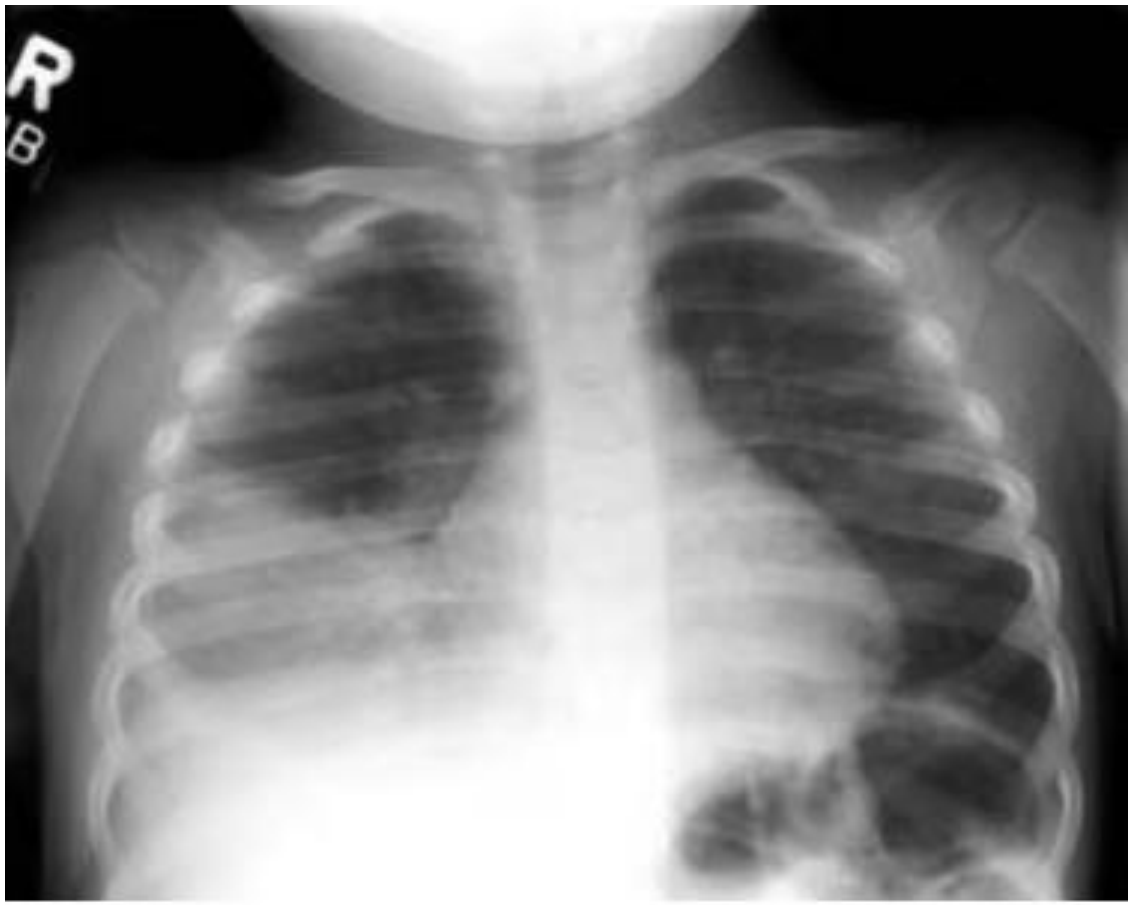
- **Clinical Manifestations**
  - Cough, rhinorrhea, sneezing, fever, wheezing, copious secretions, iWOB, apnea
  - Peak symptoms day 3-5

Bronchiolitis

- **Diagnosis**
  - Clinical
  - Further evaluation
    - CXR: Hyperinflation, peri-hilar infiltrations, patchy atelectasis
    - Respiratory viral panel

Bronchiolitis

- **Treatment**
  - First line
    - Hydration
    - Supplemental Oxygen
    - Frequent suctioning: Nasopharyngeal ”deep suctioning”
  - Alternative therapies
    - Albuterol and 3% nebulizer treatments
      - No proven benefit
    - Chest Physiotherapy
      - No proven benefit



Case Study

- Seven year old M presents with 4 days of daily fever up to 102.3F, cough and mild abdominal pain, on auscultation you hear…
- VS: T 38.9C, RR 46, HR 1146, Sat 89% on RA

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Pneumonia

- **Pathophysiology**
  - Inflammation of lung parenchyma; infiltration of alveoli with WBC and fibrinous exudate l
- **Classifications**
  - Anatomic location
  - Acquisition
    - Community vs hospital
  - Organism
    - Neonates: GBS, Klebsiella, E.coli, Listeria
    - School Age: Viral, Strep pneumo, H. influenzae type B, Mycoplasma
    - Special Populations
      - Immunocompromised, chronic medical needs/location
- **Clinical Manifestations**
  - Fever, cough, hypoxia, iWOB, lethargy, abdominal pain,
  - Exam with crackles and/or decreased breath sounds over area of consolidation

Pneumonia

- **Diagnosis**
  - Acute symptoms [fever, cough]
  - Associated adventitious findings on auscultation or new infiltrate on imaging

- **Further Evaluation**
  - Blood culture
  - CBCd
  - Inflammatory markers [CRP, PCT]
  - Respan
  - Tracheal aspirate [if intubated]

Pneumonia

- **Treatment**
  - Antibiotics
    - Non-neonatal CAP
      - Ampicillin 50mg/kg Q6H
      - CTX 75mg/kg Q24H for more severe disease
      - School age: consider Azithromycin per respiratory viral panel
      - Consider Vancomycin and Cefepime for MRSA and pseudomonal coverage respectively
  - Supportive care
    - Hydration and oxygenation
- **Complications**
  - Pleural effusion
  - Empyema
  - Pneumatoceles

Summary

Children are not small adults

Early recognition of respiratory distress is key to outcomes

Management of respiratory distress depends on the underlying etiology and corresponding needs

QUESTIONS?

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