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

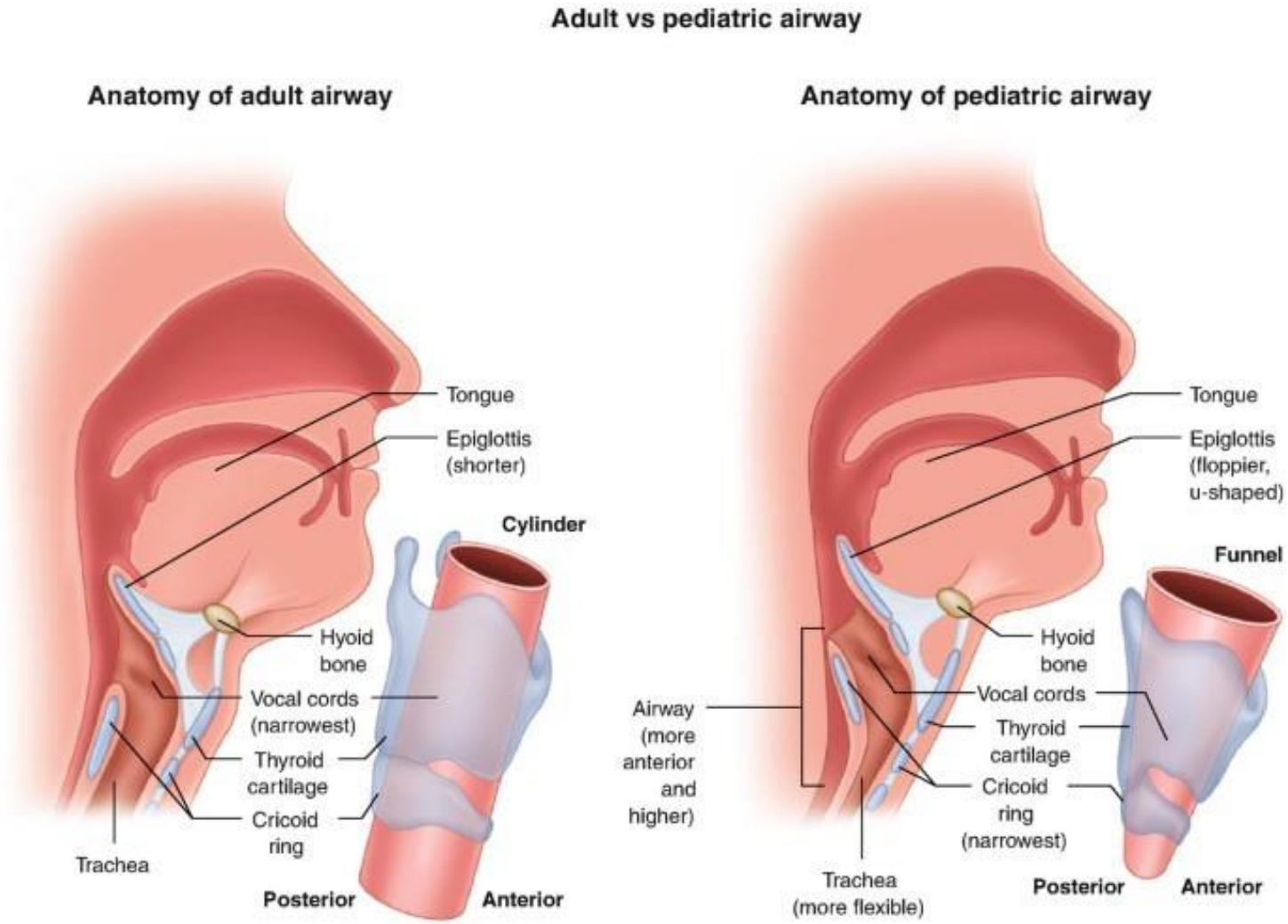
Anatomic Differences

- 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

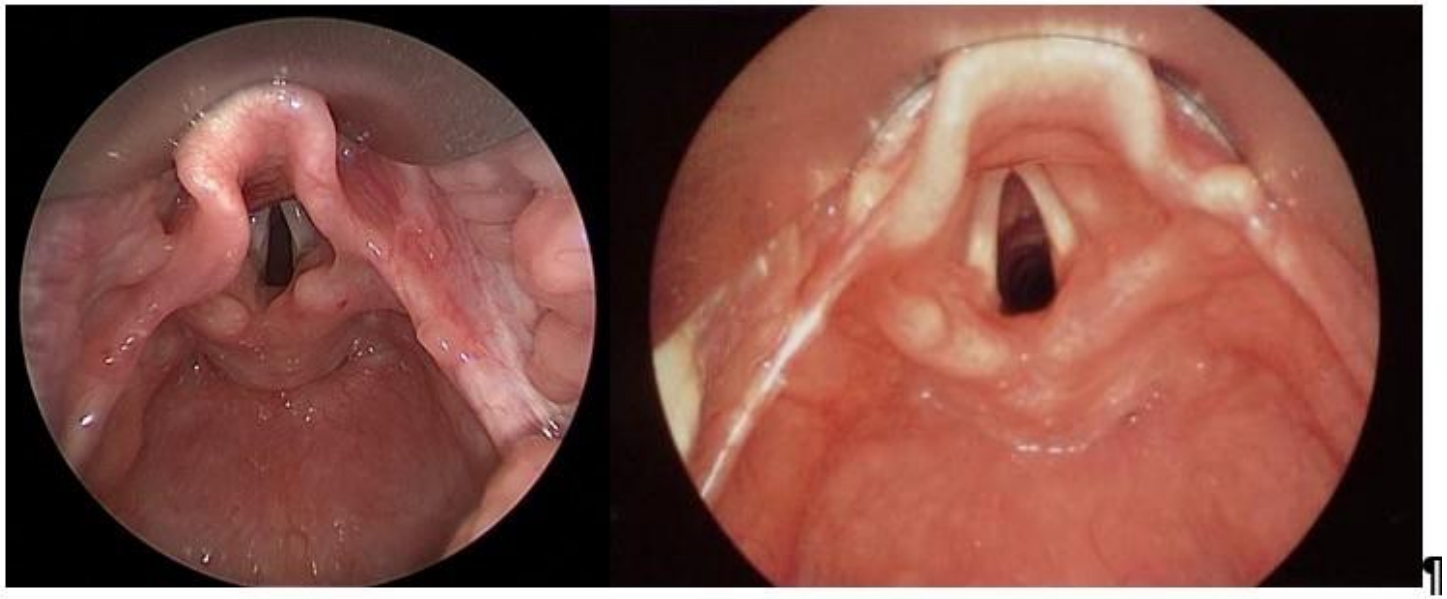
- Larynx
  - Higher in pediatrics
    - C2 in neonates
    - C3-4 in children
    - C5-6 in adults
  - Greater susceptibility to….
  - Funnel shaped: narrowest portion in subglottic space
    - Predisposes to ….



Zeretzke-Bien, Quick Hits for Ped, 2018

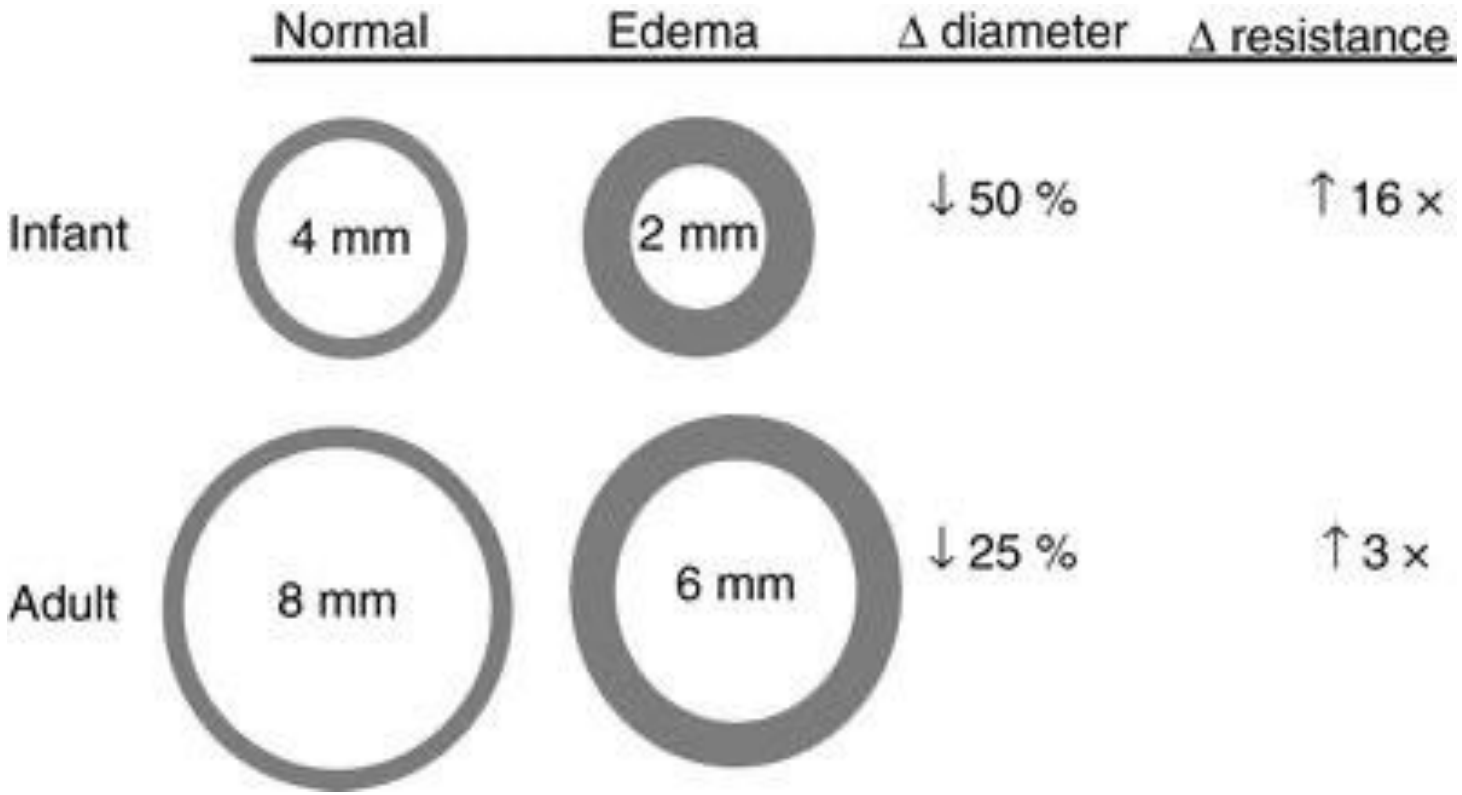
Anatomic Differences

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



Anatomic Differences

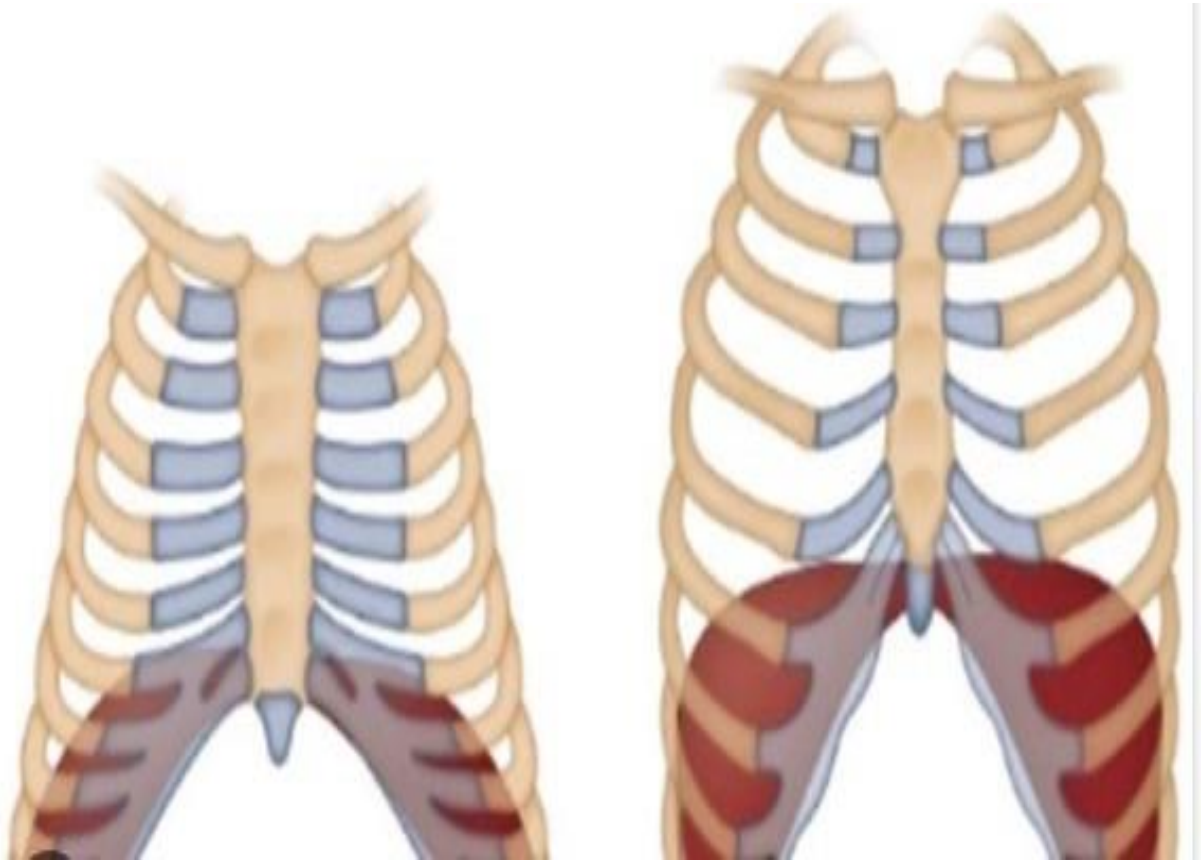
- Trachea
  - Internal diameter is 1/3 of adult
    - $R=8nl/[pi]r^4$
  - Short length creates issues with inadvertent extubations
    - Newborn: 5cm
    - 18month: 7cm



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
  - Less surface area for gas exchange



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?
      - Child leans forward on outstretched arms-to relieve upper airway obstruction by using gravity to move tonsils, redundant pharyngeal tissue forward and away from the airway

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: why is this important?
    - Unreliable in carbon monoxide poisoning and methemoglobinemia
    - Nail polish colors can falsely lower readings

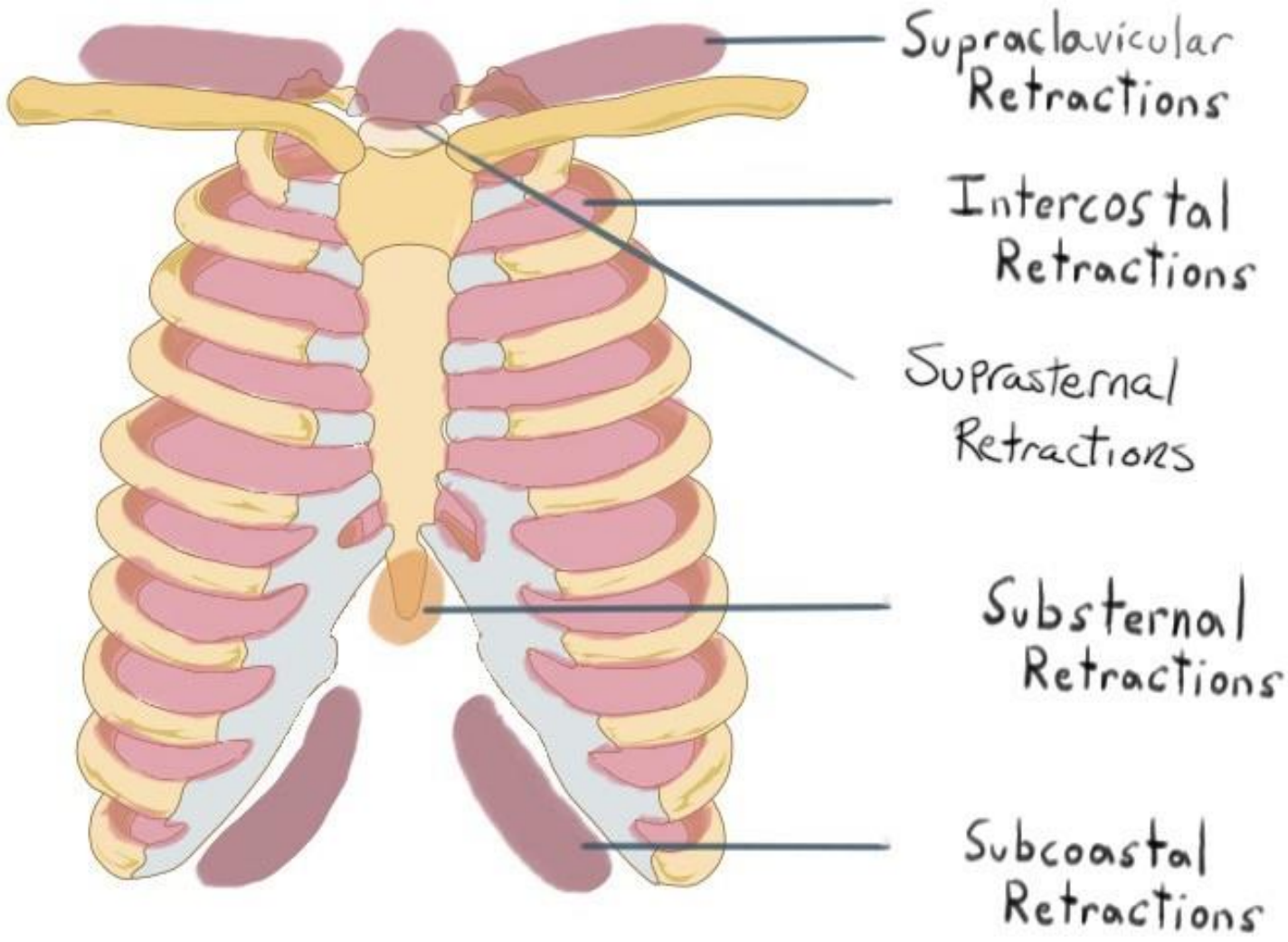
Assessment of Respiratory State

- Respiratory Rate
  - Expose chest and assess by observation

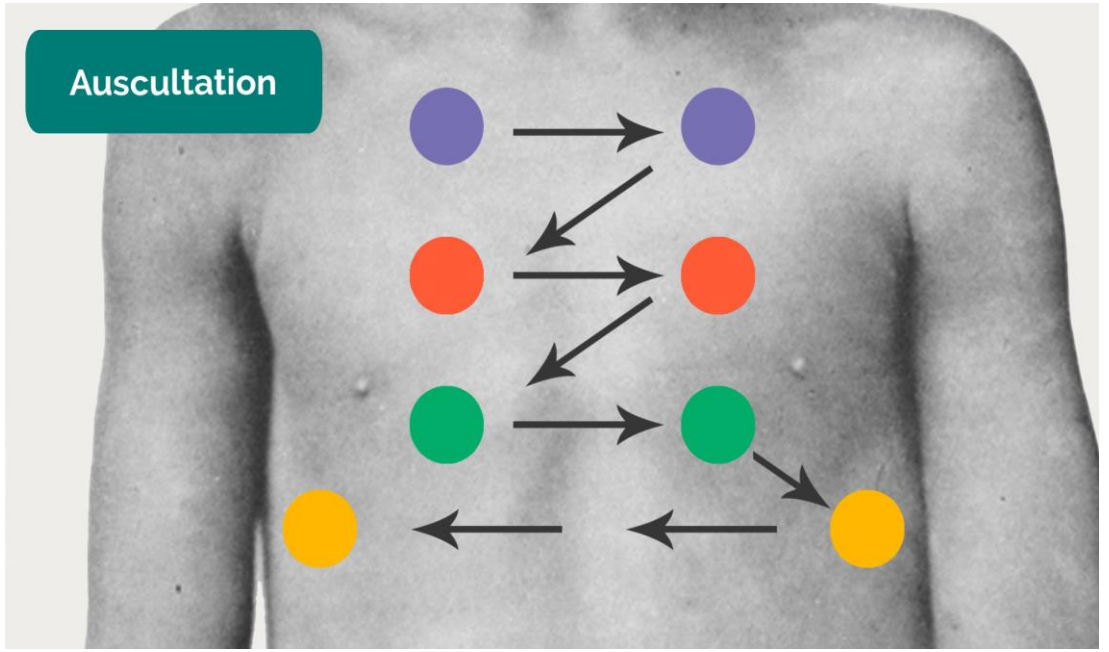
Age	Rate [breaths/min]
Infant	30-53
Toddler	22-37
Preschool	20-28
School-age	18-25
Adolescent	12-20

Assessment of Respiratory State

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

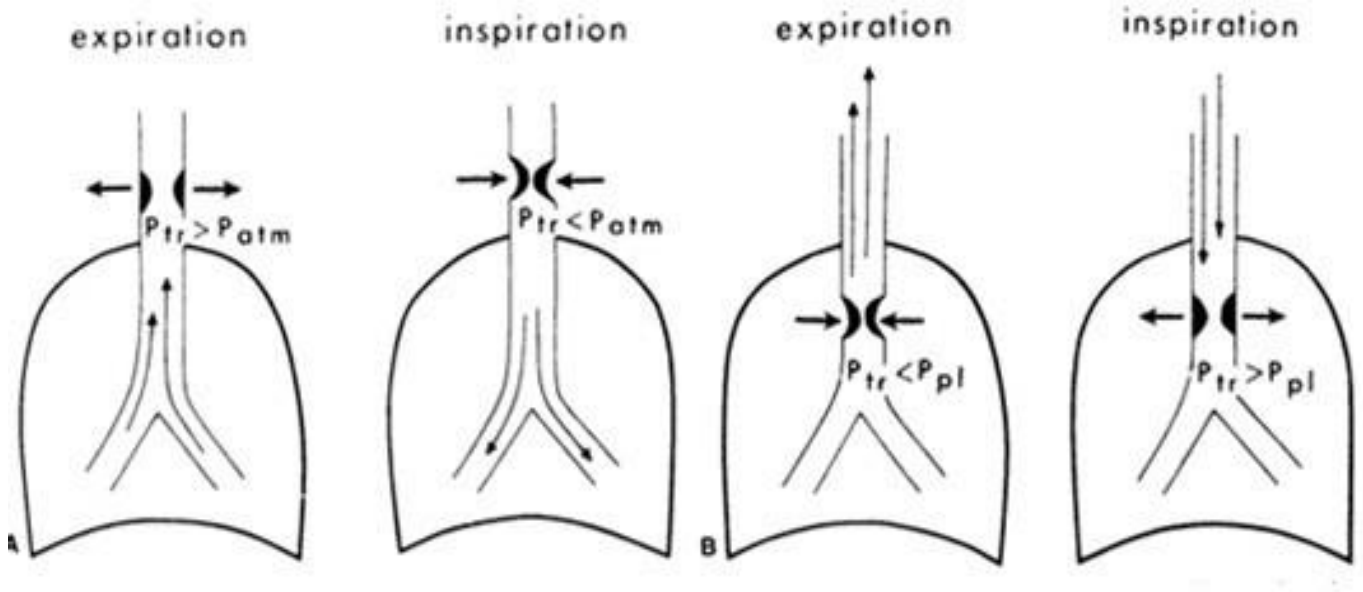


Respiratory Assessment



- 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

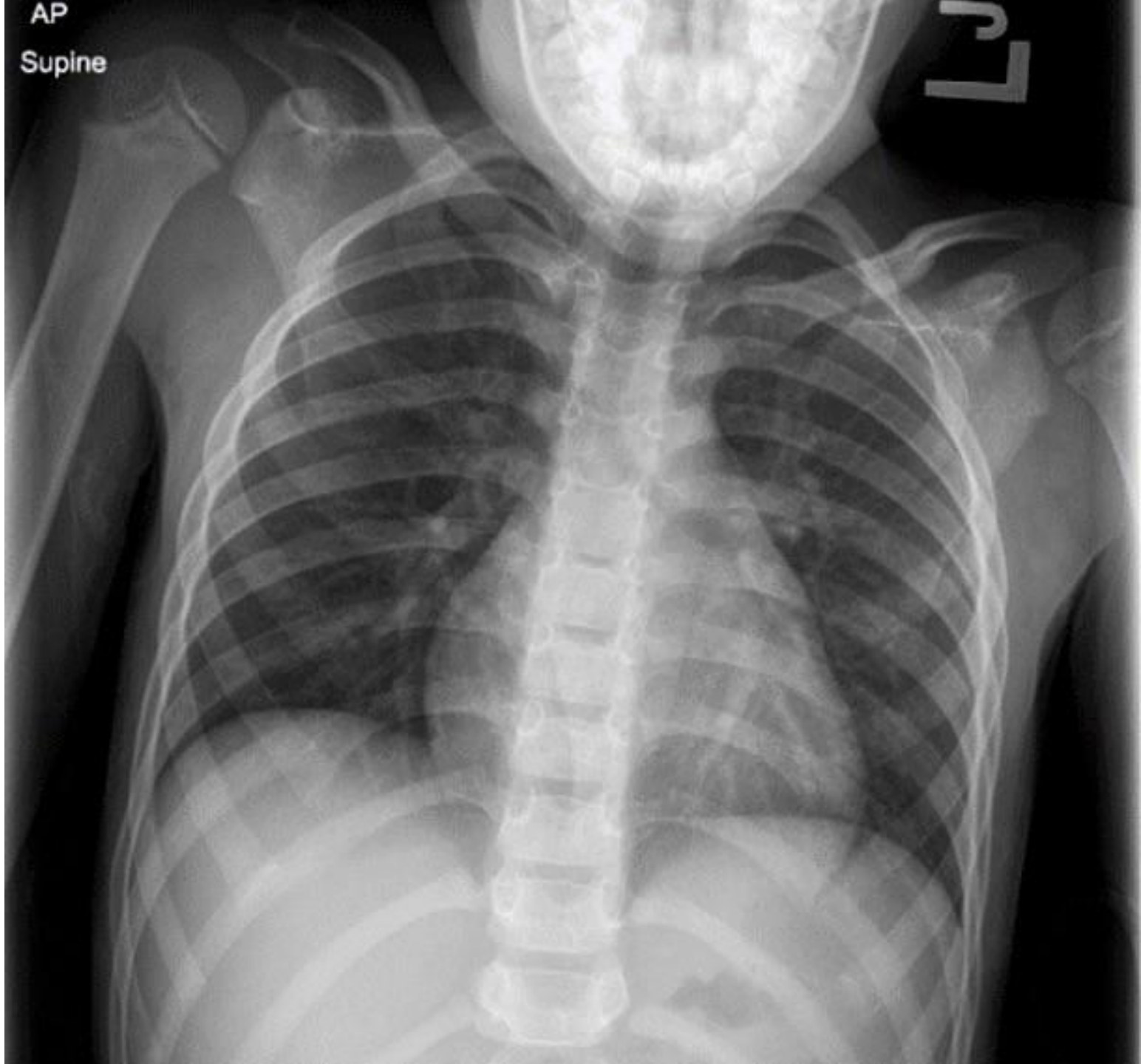


- Auscultation
  - Inspiratory noise:
    - Airway disorder from nose to subglottic by extra thoracic space
    - Extra thoracic trachea prone to collapse with inspiration=stridor
      - Occurs due to the significant negative inspiratory force created by inhaling against obstructed upper airway
  -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

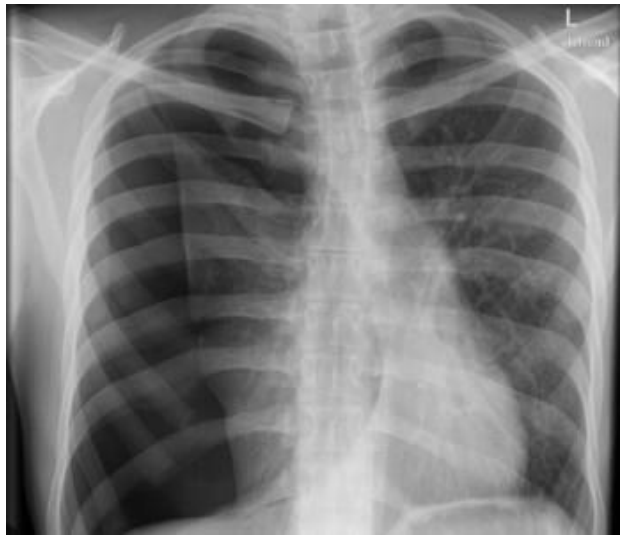
"What Determines the Major Lung Volumes?"

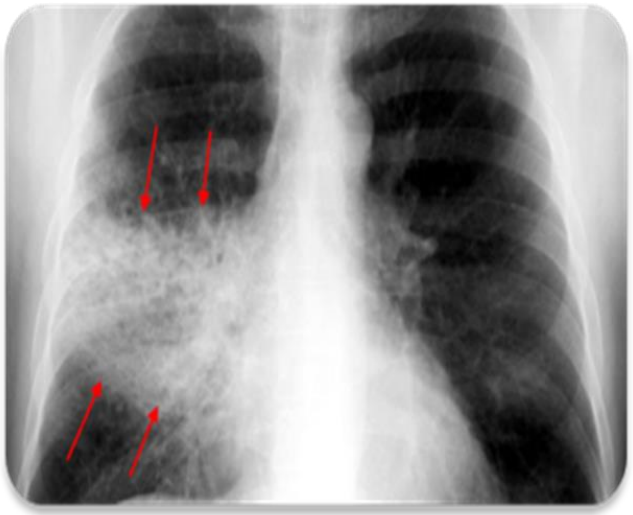
Respiratory Assessment

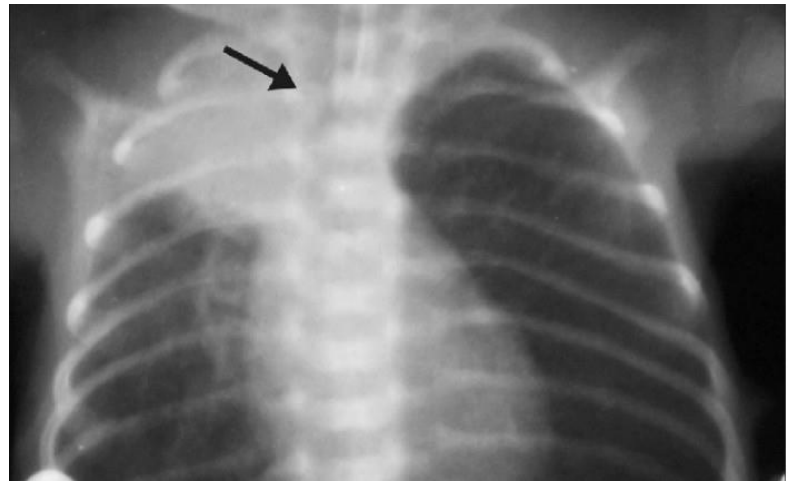
How do we read CXR’s?



CXR Interpretation







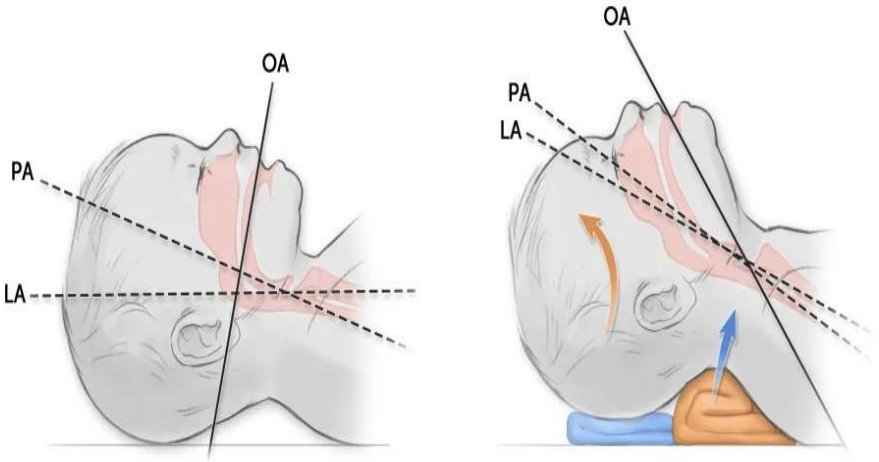
Respiratory Monitoring

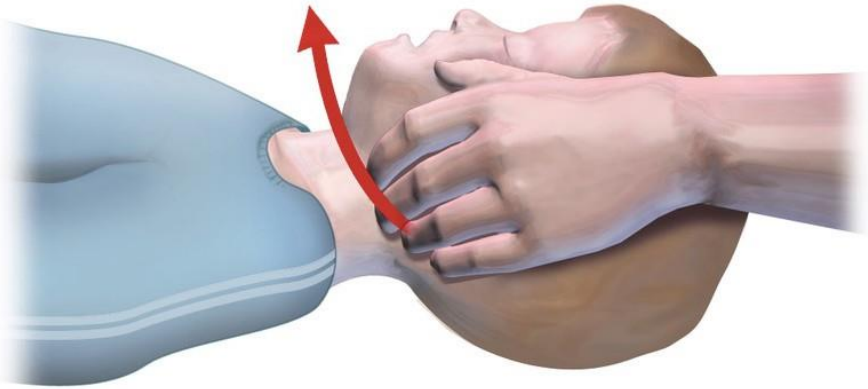
- Serial clinical assessments
- Pulse oximetry
- End-Tidal CO2
    - Estimates arterial CO2
    - Via nasal cannula or through ETT
    - With increased dead space, inaccurate reflection of arterial CO2.
- Arterial / Venous Blood Gas
    - pH/PCO2/PO2/HCO3
    - Normal values?
    - What would respiratory acidosis show?
    - What would respiratory alkalosis show?

Oxygen Delivery Devices

But first….opening a child's airway

- The goal: Aligning the oral, pharyngeal, and tracheal axes for maximal opening
- The problem
  - Children younger than than two: large head for body=slight neck flexion in supine position
    - Small roll under shoulders
    - Avoid overextension
    - Small roll under head
  - 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

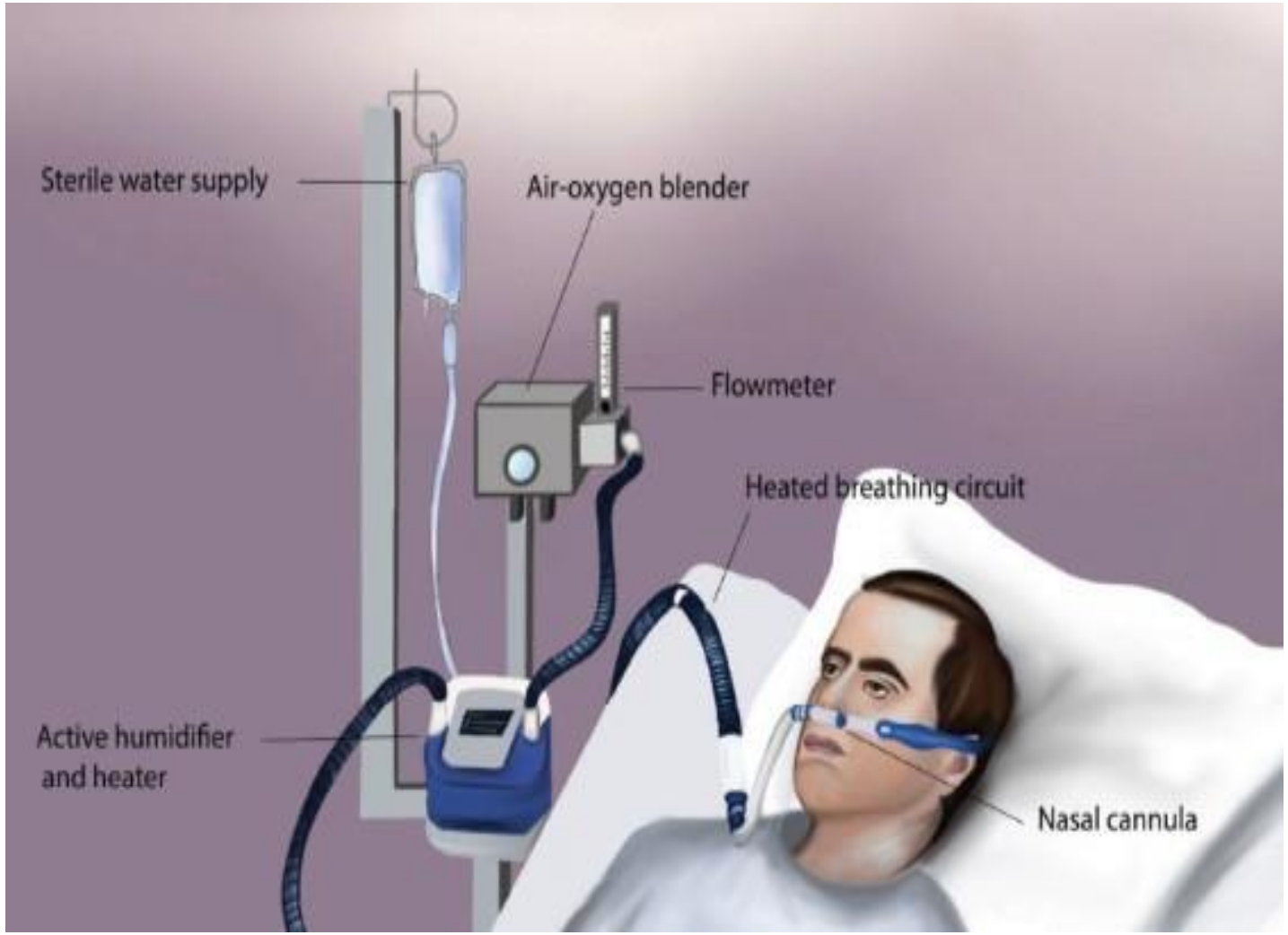
- Nasal Cannula
  - Low flow device
  - Up to ~6L
  - 3-4% FiO2 increment rise per 1L from RA

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
  - FiO2 80-90%
  - Oxygen flow rate of 10-15L 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
    - How would you manage?
  - Airway muscle laxity
    - How would you manage?
  - Hypopnea
    - How would you manage?

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 945
- CXR:
- What is your diagnosis?

Croup [Laryngotracheobronchitis]

- Pathophysiology
  - Larynx and subglottic airway edema characterized by inspiratory stridor and barking cough, most common infectious cause of upper airway obstruction in children
  - Anatomic hallmark: narrowing of subglottic airway immediately below vocal cords
    - Cricoid cartilage of subglottic space is complete cartilaginous ring; hence cannot expand
- Epidemiology
  - Age: 6months-4years
  - Seasonal: Late fall-winter
- Causes: Parainfluenza, H. influenzae, RSV, Adenovirus, Mycoplasma pneumoniae
- S&S:
  - Prodrome of rhinorrhea, low-grade fever, hoarseness, barky cough, prefer to sit up
  - Tachypnea, retractions, inspiratory stridor that worsens with agitation, may tripod

Croup [Laryngotracheobronchitis]

- Diagnosis: Clinical
  - AP/lateral neck film will show: narrowing in subglottic space: steeple sign
  - Respiratory viral panel
  - Assessing severity: Westley croup score

TABLE 2

Westley Croup Score

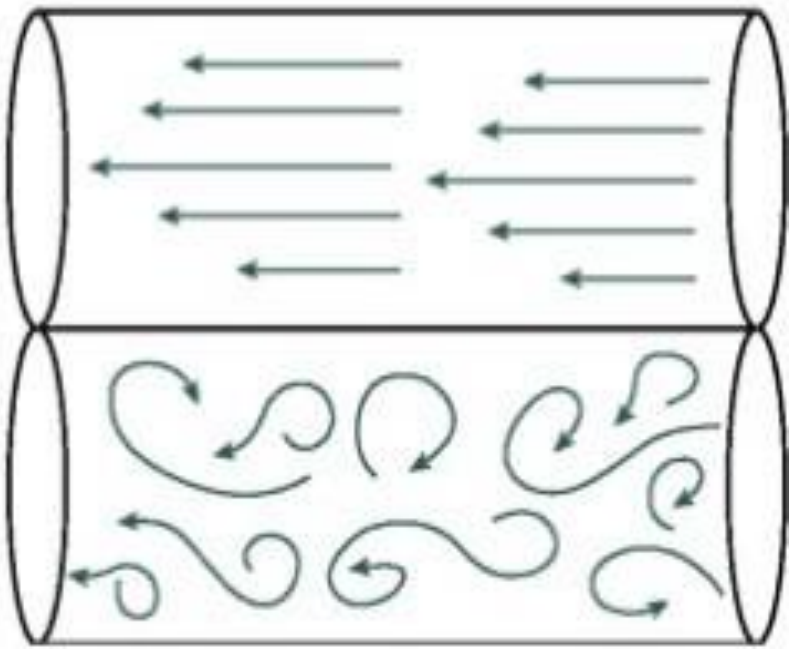
Clinical sign	Score
Level of consciousness	
Normal (including sleep)	0
Disoriented	5
Cyanosis	
None	0
With agitation	4
At rest	5
Stridor	
None	0
When agitated	1
At rest	2
Air entry	
Normal	0
Decreased	1
Markedly decreased	2
Retractions	
None	0
Mild	1
Moderate	2
Severe	3
Total score	**Croup severity**
≤ 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
      - Medication lifetime?
    - Steroids [Oral, IM, IV]
      - Dexamethasone 0.6mg/kg [max 16mg]
      - Onset of action?
    - Heliox
      - Helium and oxygen
      - Lighter gas
      - 60/40, 70/30, 80/20 concentrations



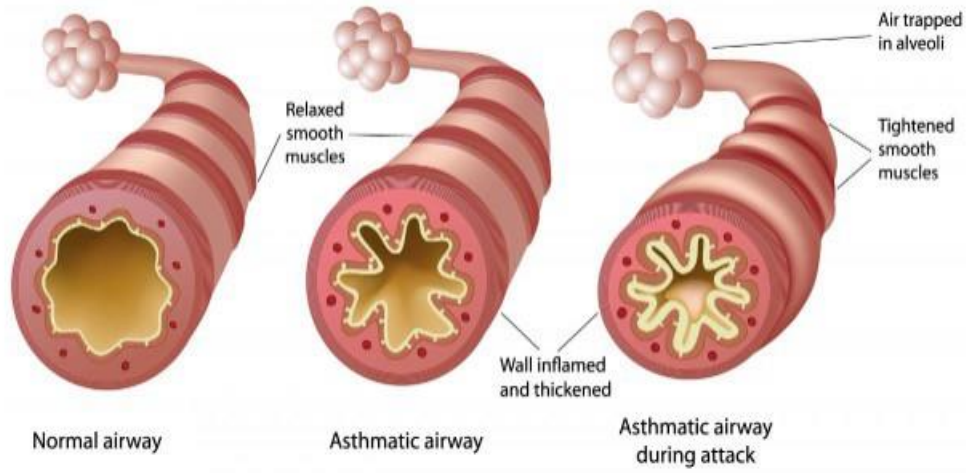
Herman, J.B, *Annals of the American Thoracic Society, 2017*

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
- CXR:
- What is your diagnosis

Asthma

- Chronic inflammatory lung disorder marked by recurring episodes of airway obstruction
    - Bronchospasm [smooth muscle spasm]
    - Mucosal edema
    - Mucous plugging
  - Obstruction impedes expiratory airflow results in air trapping, hyperinflation➔expiration becomes active process
- Epidemiology:
  - Most common chronic disease of childhood
- Triggers:
  - Exercise
  - Reflux
  - Allergen or airway irritant exposure
  - Viral infections
  - Weather change



"Asthma Pathophysiology " 2019

Asthma

- Important historical information
  - Frequency of symptoms: cough, wheezing, chest tightness, SOB
    - Nighttime symptoms
    - Interference with daily activity
  - Short acting B-agonist use and compliance with controller
  - 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 on auscultation

Asthma

- Diagnosis
  - Clinical
  - Further evaluation
    - CXR: If first time wheezing, concern for infectious bacterial process, poor response
      - Hyperinflation,flattened diaphragm common
    - CBC: Why?
      - Leukocytosis may be secondary to steroids
    - Electrolytes
      - Potassium? Magnesium?
    - Respiratory viral panel
    - Respiratory Distress Score [RDS}

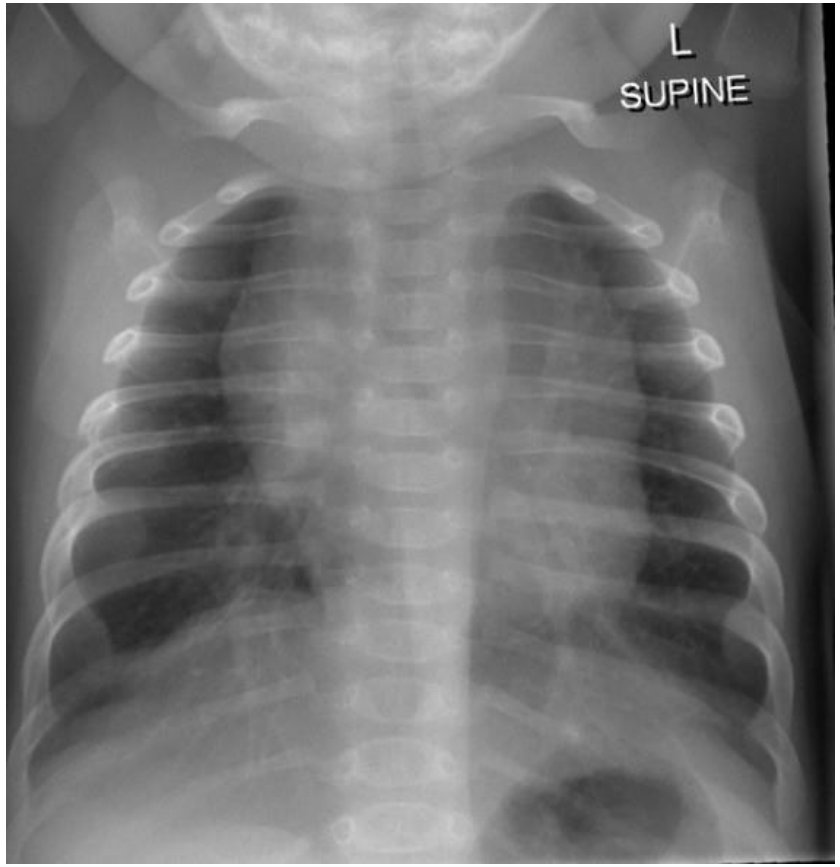
System	0	1	2	Score
Accessory muscle use	Absent or mild retractions	Moderate retractions	Severe retractions, nasal flaring	
Auscultation	No wheezing or end-expiratory wheezing only	Expiratory wheeze throughout	Inspiratory and expiratory wheeze or breath sounds becoming inaudible	
O2 saturation on RA	Greater 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
      - Continuous: 0.5mg/kg/hr with max 20mg
    - Anticholinergics: Bronchodilation
      - Evidence?
    - Corticosteroids: Suppress components of inflammatory process
      - Loading dose 2mg/kg followed by 1mg/g BID
      - Onset of action?
  - Further therapies
    - Magnesium sulfate: CCB with associated bronchodilation, inhibits smooth muscle contraction
      - 50mg/kg Q6H x 4doses
    - Intravenous B-agonists: In severe status asthmaticus with limited distribution of inhaled B-agonist
      - Terbutaline infusion: relative B2-agonist

Case Study

- One month old M, previously 34WGA presents to ED with 1 week of rhinorrhea and cough. Tried siblings Albuterol nebulizer at home every 6 hours without improvement. 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%
- CXR:
- What is your diagnosis?



Bronchiolitis

- Pathophysiology
  - Acute inflammation of the lower respiratory tract resulting in obstruction of small airways with associated copious respiratory tract secretions
  - Common causes: RSV, HMPV, RE, Coronavirus, Adenovirus, influenzae, parainfluenza
  - Typically <2y, peak 2-8months
- Risk factors for severe disease
  - Prematurity, congenital heart lesions, BPD, immunosuppression
- S&S
  - Cough, rhinorrhea, sneezing, fever, wheezing, peak day 3-5
  - Wheezing, tachypnea, increased WOB, apnea, cyanosis, copious secretions

Bronchiolitis

- Diagnosis
  - Clinical
  - Further evaluation
    - CXR: Hyperinflation, peri-hilar infiltrations, patchy atelectasis
    - CBC?
    - 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
- CXR:

Pneumonia

- Pathophysiology
  - Inflammation of lung parenchyma caused by viral or bacterial source; infiltration of alveoli with WBC and fibrinous exudate leads to worsening cause exchange and respiratory compromise
- 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
- S&S:
  - Fever, cough, dyspnea, lethargy, poor appetite, abdominal pain
  - Crackles on exam, decreased breath sounds over area of consolidation, tachypnea, increased WOB, hypoxia

Pneumonia

- Diagnosis
  - Acute symptoms [fever, cough]
  - Associated adventitious findings on auscultation [crackles] or new infiltrate on imaging
    - CXR: Necessary
- Further evaluation
  - Blood culture [especially if admitting and starting antibiotics]
  - 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 support needs

QUESTIONS?

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