Pediatric Respiratory Emergencies

Children's Hospital Colorado

Affiliated with University of Colorado Anschutz Medical Campus School of Medicine

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Financial Disclosures

I have no relevant financial interests to disclose.

Objectives

Review	Review the pediatric airway and signs/symptoms of respiratory distress in pediatric patients.
Introduce	Introduce a systematic approach to pediatric respiratory distress
Discuss	Discuss the causes and treatment options for common pediatric respiratory issues using some case examples
Review	Rapid review of most recent literature/studies as time allows

Polling Question: Getting to Know the Audience

What is your role?

- APP
- EMS
- Nurse
- Physician
- Respiratory Therapist
- Other

Polling Question: Getting to Know the Audience

What is your practice setting?

- Emergency/Urgent Care
- Inpatient: Pediatrics, ICU etc.
- Outpatient: PCP, Specialty care etc.
- Pre-Hospital
- Other

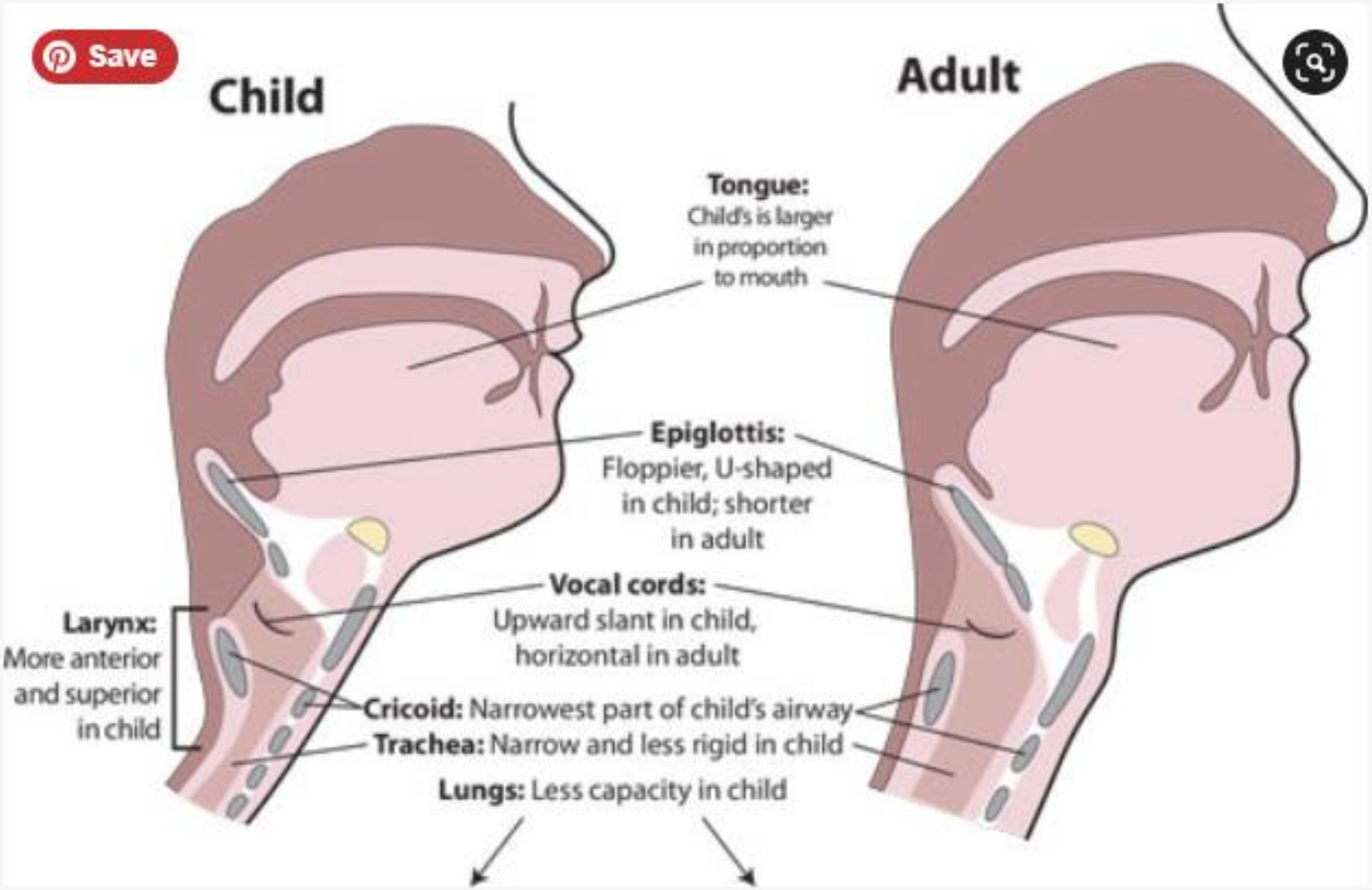


Figure 1: Pediatric vs. adult upper airway anatomy

Positioning

Proportionally larger head, particularly the occiput (up to ~8yrs)

Laying flat will obstruct the airway

Positioning with towel rolls can straighten the neck and open the airway

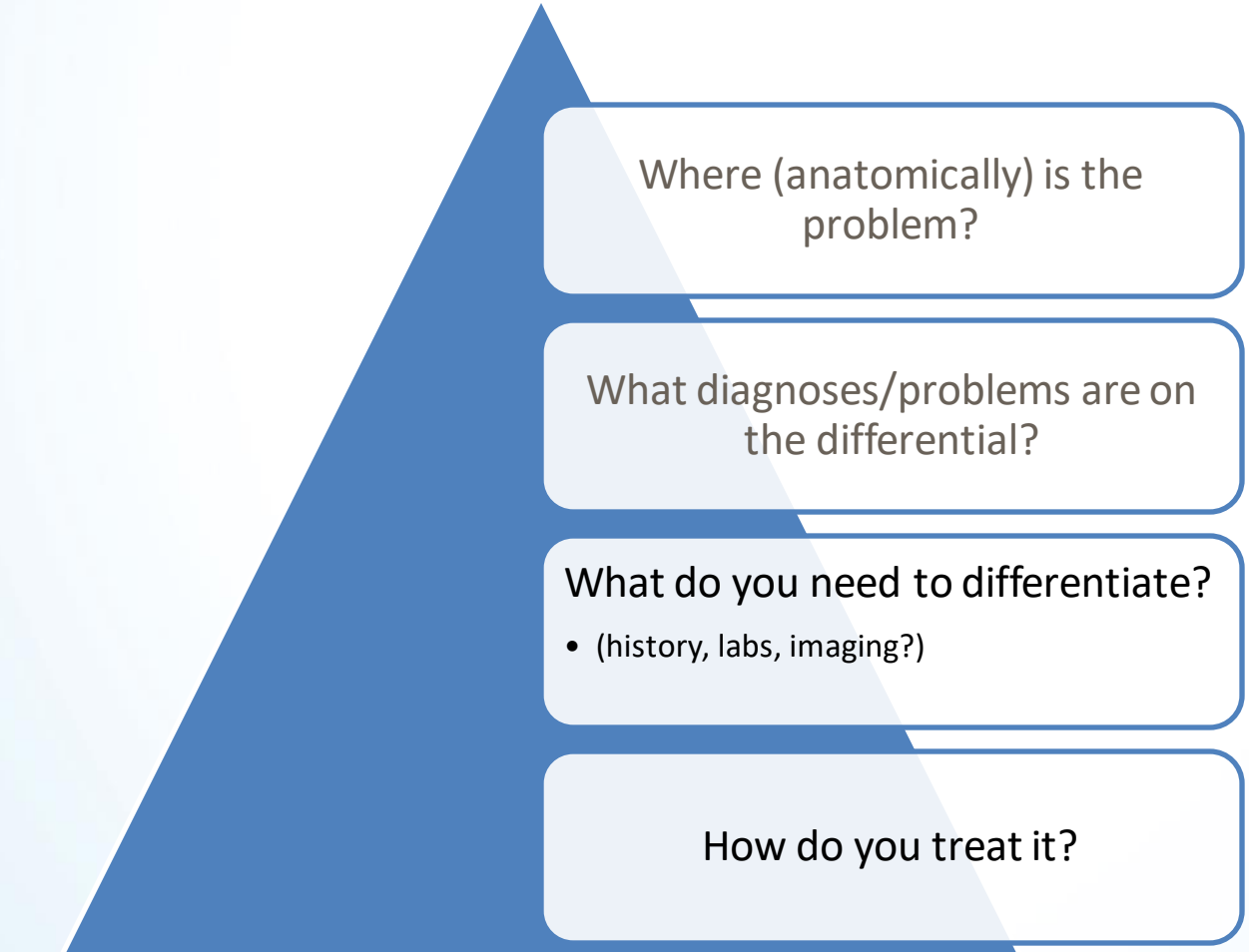
Signs of Respiratory Distress

Early Signs	Late Signs
Nasal flaring	Cyanosis
Tachypnea (age dependent!)	Somnolence, hypotonia
Belly breathing, subcostal retractions, tracheal tugging	Sternal and intercostal retractions
Noisy breathing: stertor, wheezing, stridor (without work of breathing)	Poor peripheral perfusion (cold, cap refill >3 sec)
	Altered mental status
	Apnea

Normal Vitals Ranges by Age

Age Group	Heart Rate	Resp Rate	Systolic BP	Diastolic BP	Wt in Kg
Birth-28 days	100-205	40-60	67-84	35-53	2-5
Infant (1mo-1yr)	100-180	30-53	72-104	37-56	3-10
Toddler (1-3yr)	98-140	22-37	86-106	42-63	10-14
Preschooler (3-5yr)	80-120	20-28	89-112	46-72	14-18
School Age (5-11yr)	75-118	18-25	97-115	57-76	20-40
Adolescent (12 and up)	60-100	12-20	110-131	64-83	>40

Step by Step Approach

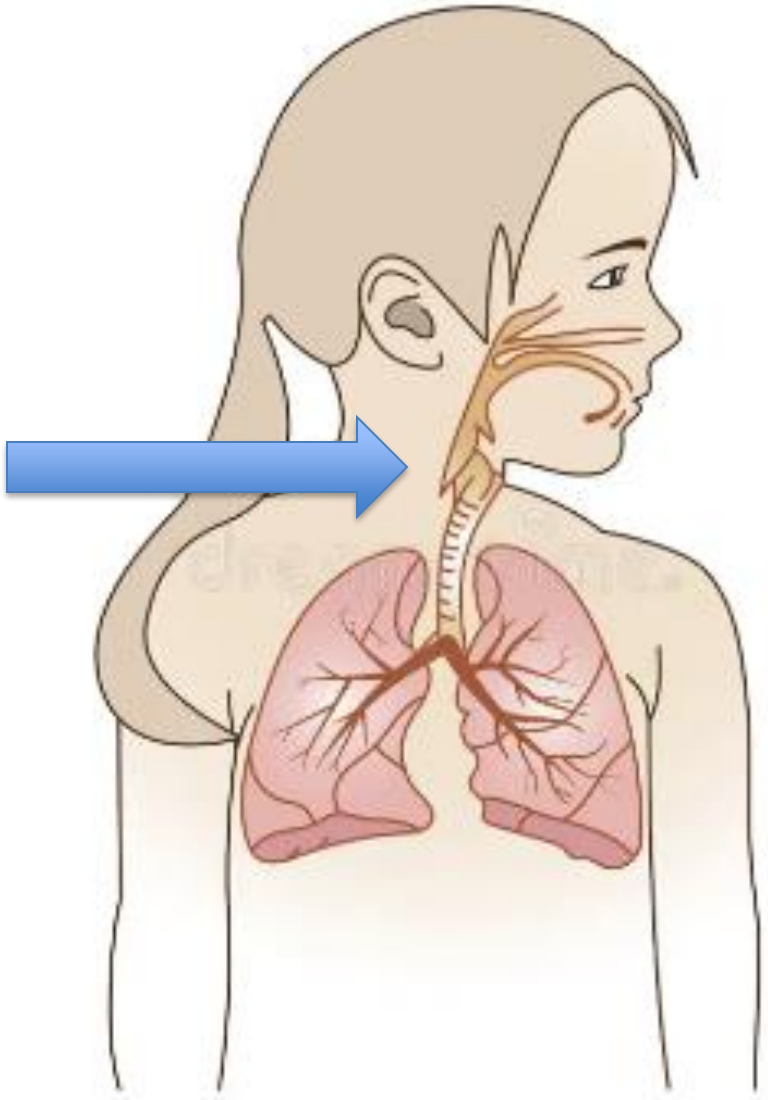


Case #1

Step by Step Approach

Where (anatomically) is the problem?

Upper Airway



Noise Definitions

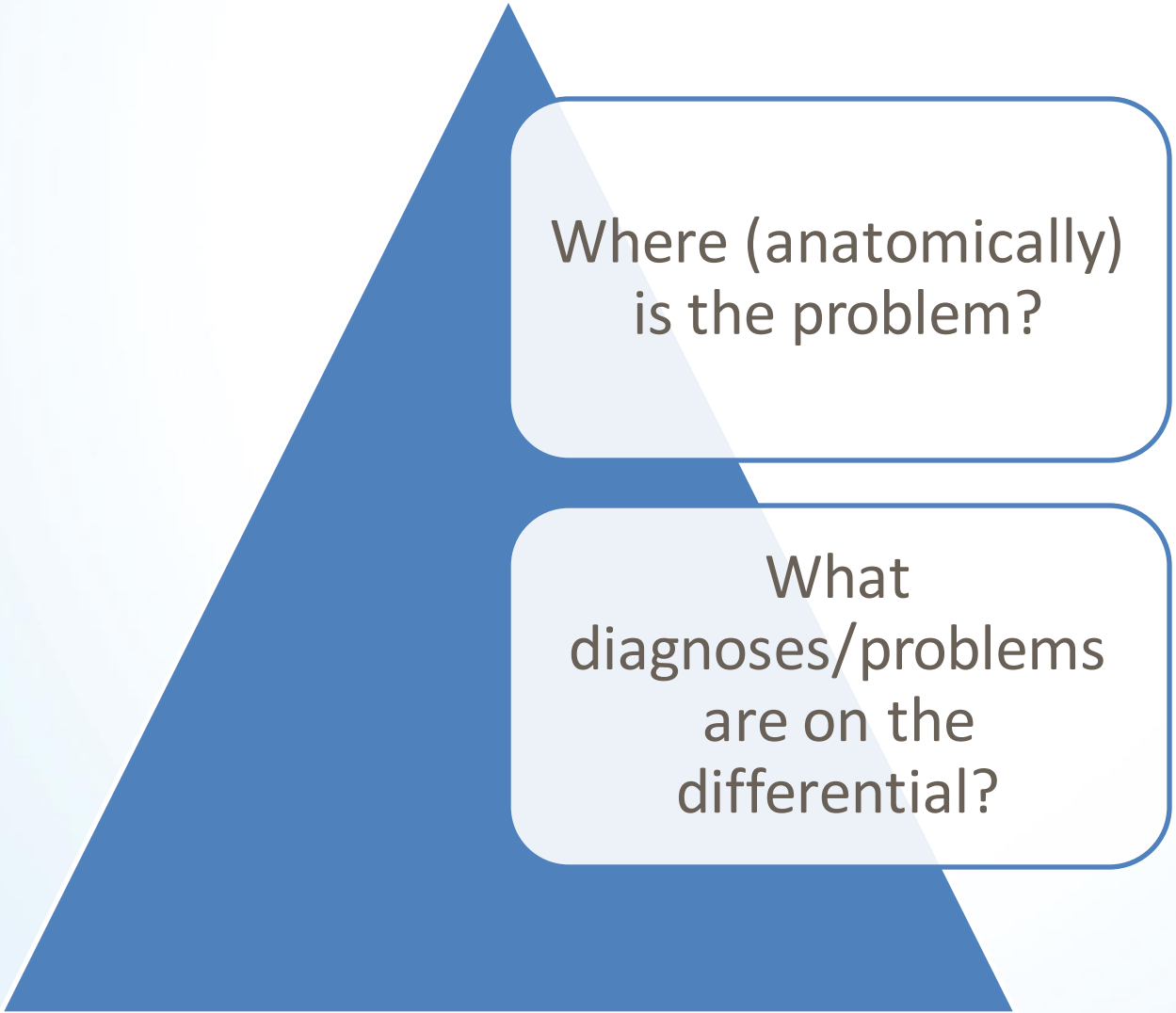
Stertor:

- Rhoncorous/"snoring", coarse, wet, lower pitched
- Inspiratory AND expiratory (usually)
- Primarily a secretions problem
- Primarily *above* the larynx

Stridor

- High pitched, "whistle", "squeak"
- Inspiratory
- Narrowing of the airway due to inflammation or obstruction
- Usually at or below the level of the vocal cords

Step by Step Approach



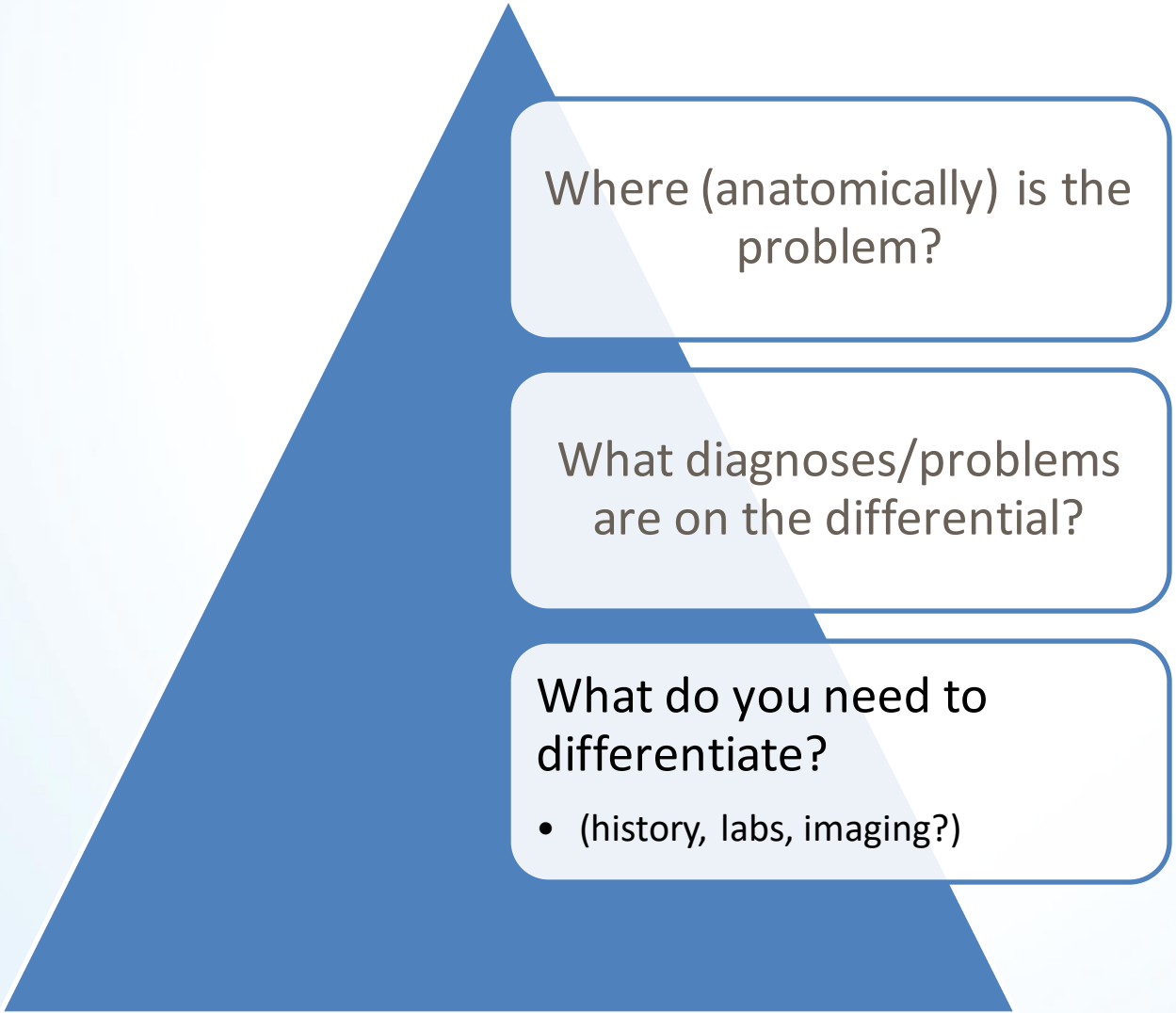
Polling Question

What diagnoses/problems are on the differential for this patient?

Upper Airway Obstruction

- Croup aka laryngotracheitis
- Foreign Body Aspiration
- Anaphylaxis
- Bacterial Tracheitis
- Epiglottitis
- Laryngospasm
- Laryngomalacia/tracheomalacia
- External airway compression (masses, vascular rings/slings)

Step by Step Approach



Where (anatomically) is the problem?

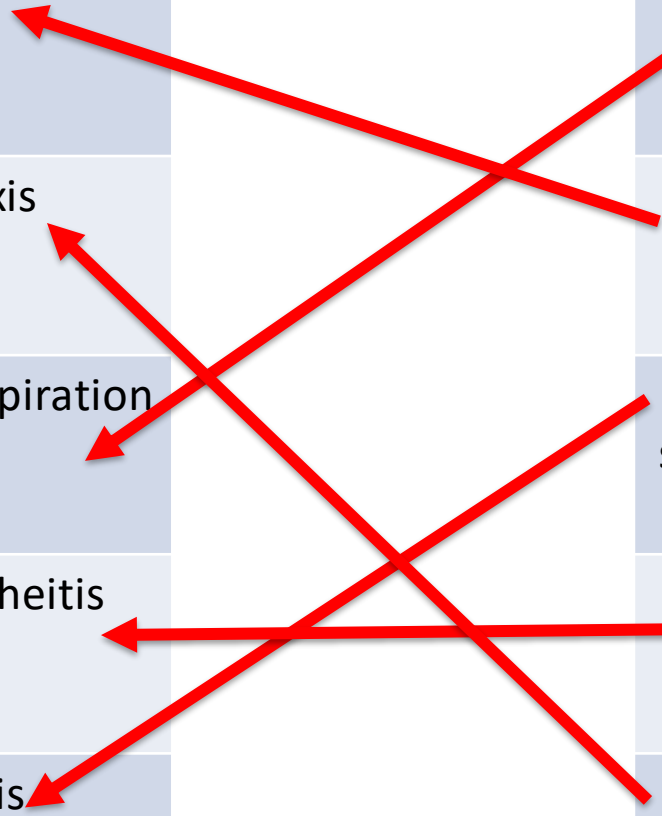
What diagnoses/problems are on the differential?

What do you need to differentiate?

- (history, labs, imaging?)

Upper Airway Obstruction

Problem	History
Croup	Was well, suddenly developed difficulty breathing after playing in other room
Anaphylaxis	Fever and harsh cough x1-2 days, cough and noisy breathing worse at night
Foreign Body Aspiration	Unvaccinated child, 1-2d fever, comes in with severe respiratory distress, tripoding, drooling
Bacterial Tracheitis	Croupy cough and stridor last 3-4 days, not getting better, +/- ongoing fevers
Epiglottitis	Child with tree nut allergy, ate new brand of granola bar, a few minutes later struggling to breathe

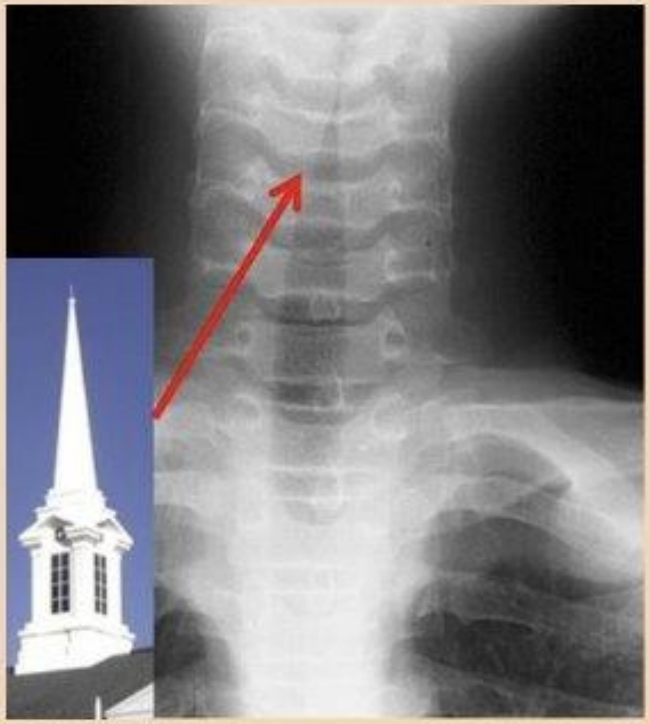


Upper Airway Obstruction

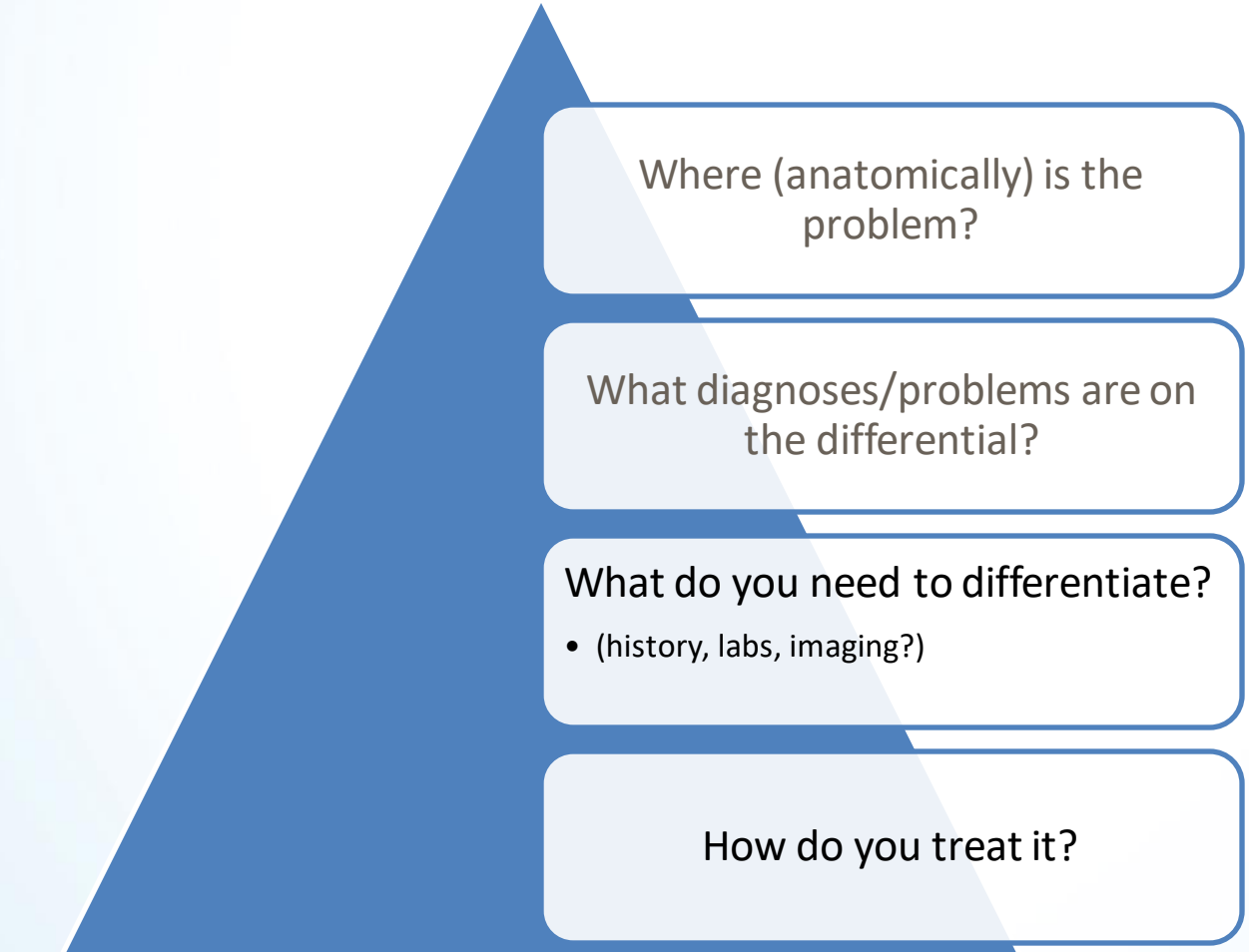
Problem	Work up?
Croup	History/Exam
Foreign Body Aspiration	XR (including lateral neck and AP neck & chest)
Anaphylaxis	History/Exam
Bacterial Tracheitis	History +/- direct flex laryngoscopy
Epiglottitis	History/Exam Lateral neck XR

Thumb sign (Epiglottitis)

Steeple sign (Croup)



Step by Step Approach



Upper Airway Obstruction

Problem	Treatment
Croup	Systemic steroids (Dex) Racemic epinephrine
Foreign Body Aspiration	Removal via bronchoscopy or endoscopy if esophageal
Anaphylaxis	IM Epi (q5-15min as needed) Cetirizine/diphenhydramine for pruritis *No proven benefit to steroids/H2 blockers unless asthma symptoms*
Bacterial Tracheitis	Secure airway Antibiotics (CTX or unasyn + vanc or linezolid)
Epiglottitis	Secure airway Antibiotics (same as for bacterial tracheitis)

Heliox for upper airway obstruction

ORIGINAL RESEARCH

Laryngoscope Investigative Otolaryngology

Outcomes of heliox use in children with respiratory compromise: A 10-year single institution experience

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Abstract

Objective: Heliox, a mixture of helium and oxygen, has been shown to improve laminar airflow and decrease airway resistance in children. This study aims to describe the outcomes of heliox use in children with respiratory compromise and to identify variables associated with a need for airway surgical intervention.

Methods: A retrospective cohort study of patients who received heliox between 2012 and 2022 at a tertiary care children's hospital.

Results: A hundred and thirty-eight heliox treatments were recorded in 119 children. Twelve patients were excluded. Most ($n = 100$, 84%) patients had significant comorbidities. On average, patients spent a cumulative mean of 94 ± 187 h on heliox therapy per hospital admission. Patients with croup or asthma without known airway pathology presented at an older age than patients with other indications for heliox therapy (4.0 ± 4.7 vs. 2.2 ± 3.6 years, $p = 0.04$) and were significantly less likely to have background diseases ($n = 14$, 52% vs. $n = 74$, 93%, $p < 0.0001$). Overall, 51 (47.7%) patients were recommended tracheostomy placement, airway reconstruction, or palliative care. Cumulative use of heliox for more than 47 h was associated with an increased risk of needing tracheostomy or airway reconstruction (odds ratio 6.2, 95% confidence intervals 2.56–14.13, $p < 0.0001$). In multivariable regression analysis, neuromuscular disease, intracranial neuropathology, and cumulative time of heliox were associated with a need for definitive airway intervention.

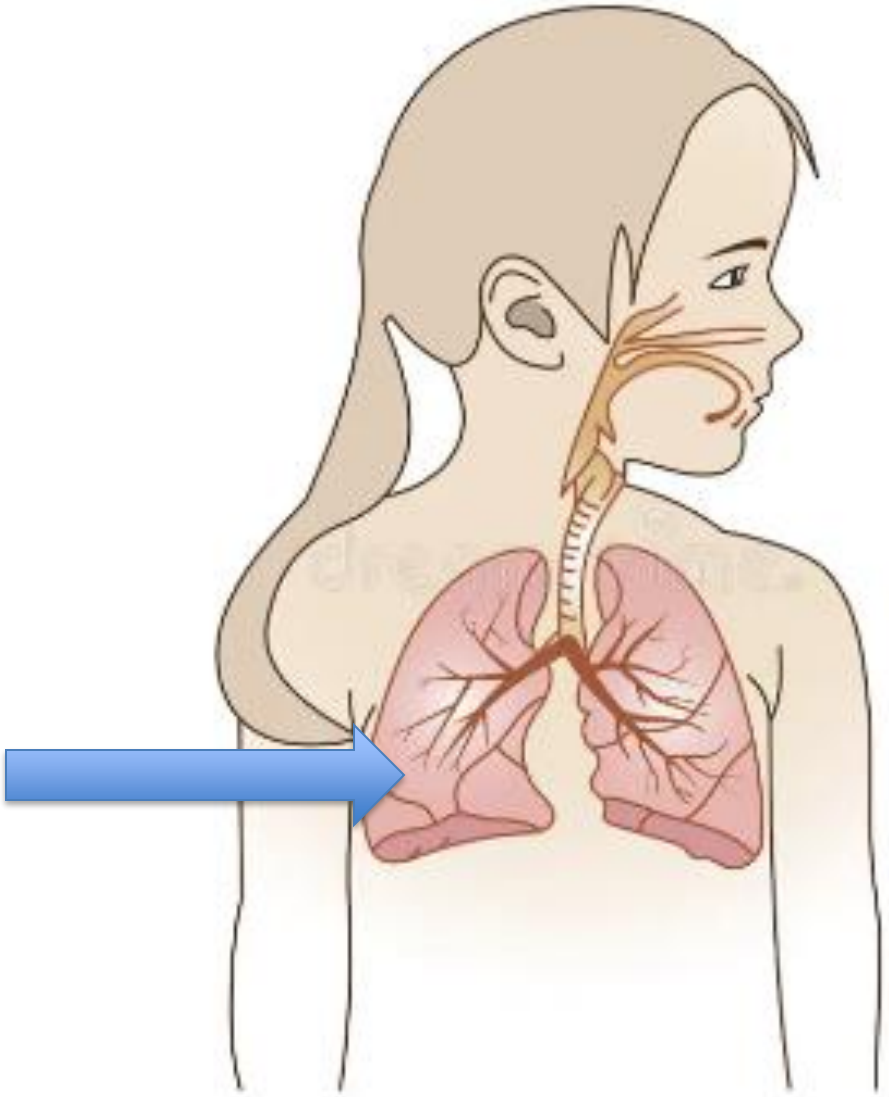
Conclusions: Heliox may be used as a temporizing agent in children with upper airway obstruction. The effectiveness of heliox use for more than 47 h in children,

Case #2

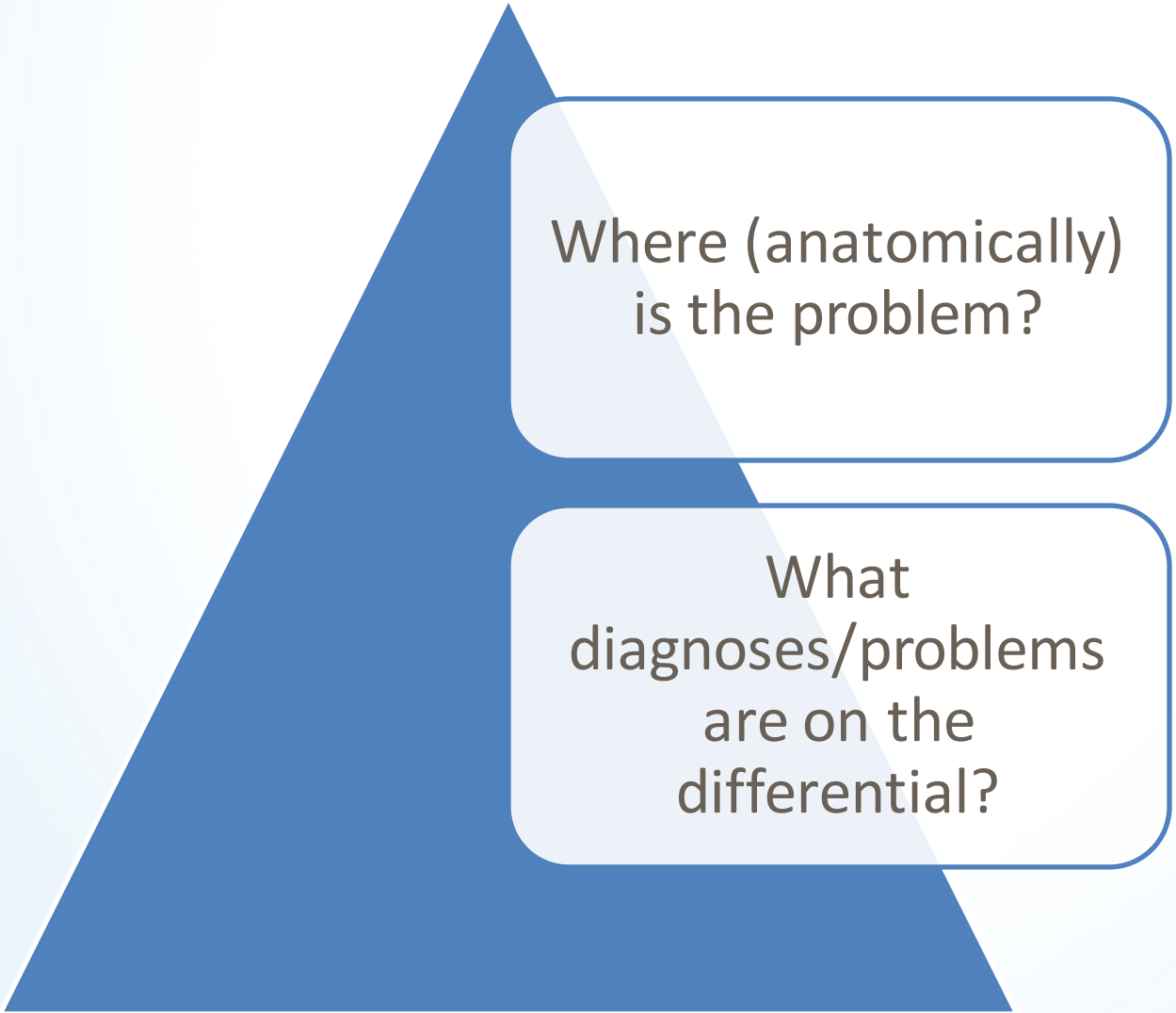
Step by Step Approach

Where (anatomically) is the problem?

Lower Airway



Step by Step Approach



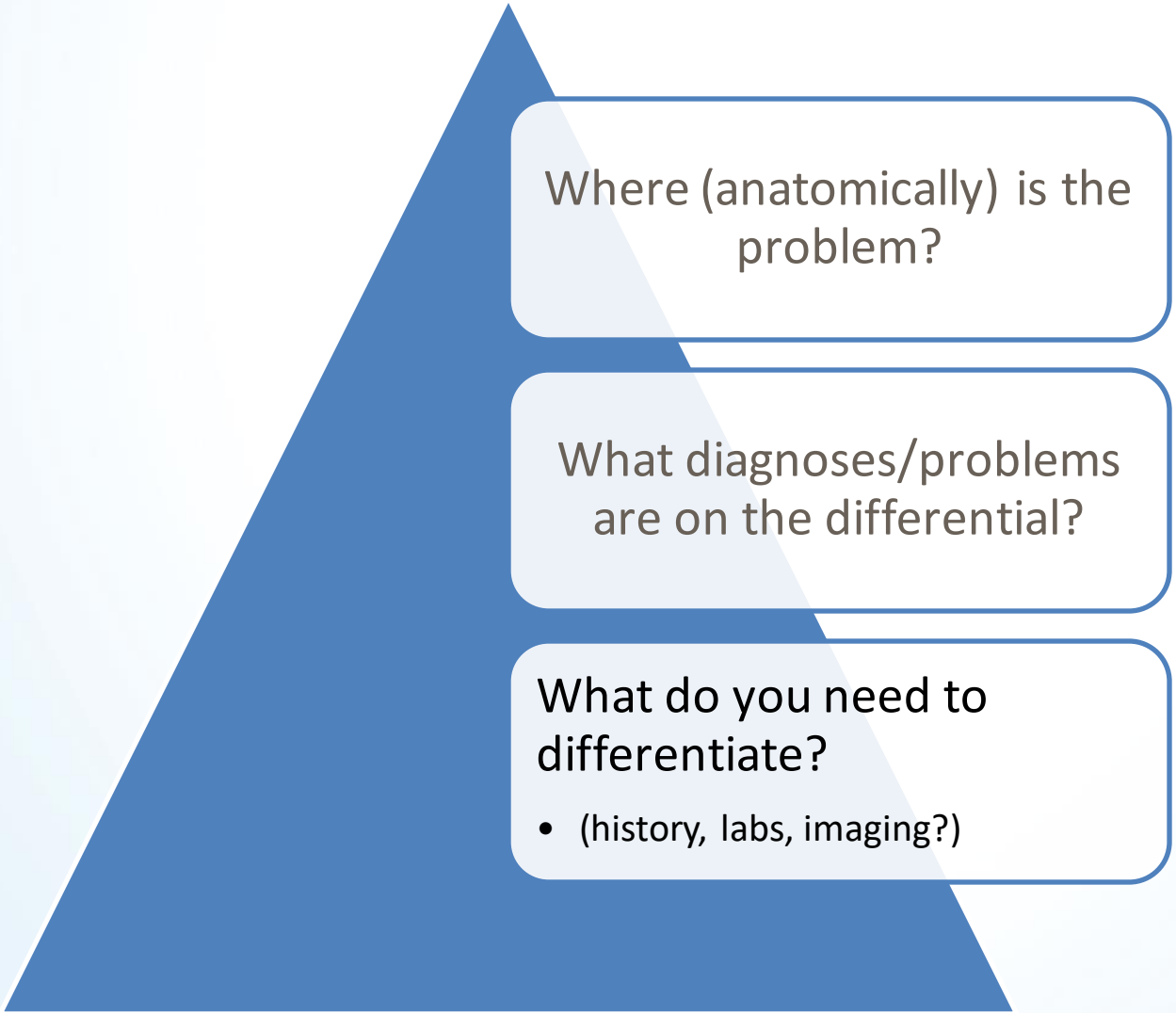
Polling Question

What diagnoses/problems are on the differential for this patient?

Lower Airway Pathology

- Asthma
- Bronchiolitis/Viral Pneumonia
- Bacterial Pneumonia
  - Community acquired
  - Aspiration pneumonia
  - Atypical bacterial (mycoplasma, chlamydia)
- Pneumothorax
- Pulmonary Edema
- Thoracic/mediastinal masses

Step by Step Approach



Where (anatomically) is the problem?

What diagnoses/problems are on the differential?

What do you need to differentiate?

- (history, labs, imaging?)

- Hx of asthma?
- 2 weeks of congestion now new fevers and WOB?
- 2 days of URI symptoms?
- Coughing/choking with feeds? And or aerodigestive abnormality?
- Summiting 14er?
- Eczema, alleries and prior viral induced wheeze?

Bronchiolitis vs Asthma

Bronchiolitis

Typically younger kids (<2)

Wet cough

Coarse crackles

Stertor ("wheeze" w/o stethoscope)

Mucous mucous mucous

Usually viral symptoms (rhinorrhea, fevers)

Seasonal

Asthma

Typically older kids (>2)

Tight/dry cough

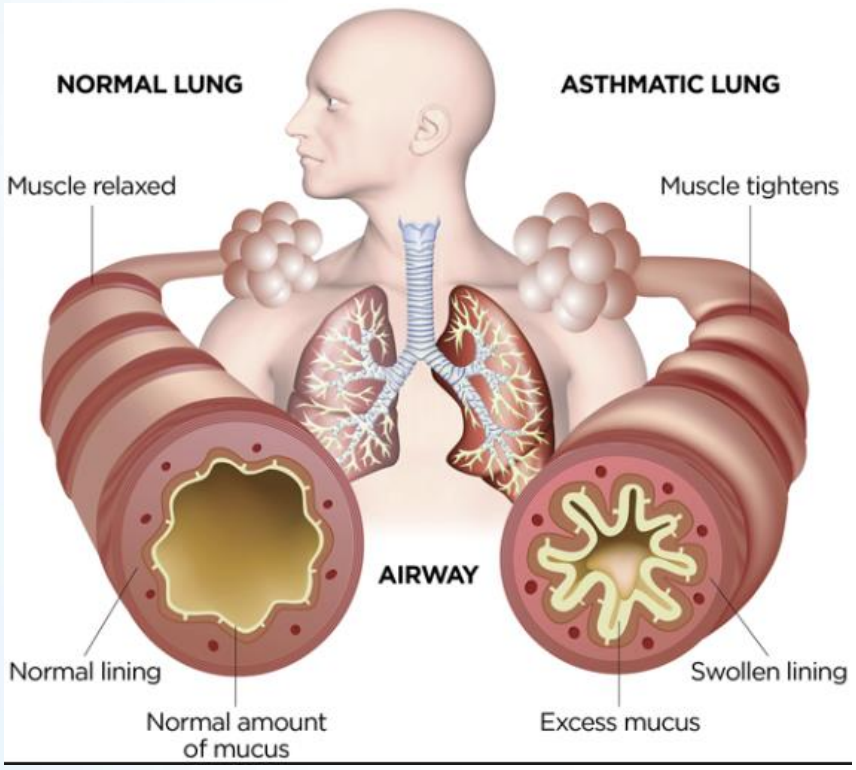
Diminished aeration

Prolonged expiratory phase (air trapping)

Expiratory wheeze (sometimes inspiratory)

May have viral symptoms, but not necessarily

Asthma



What is the problem?

- Intramural inflammation of the small airways
- Air gets trapped during exhalation-->wheeze
- Triggers include viruses, allergens, irritants (smoke), exercise, weather changes

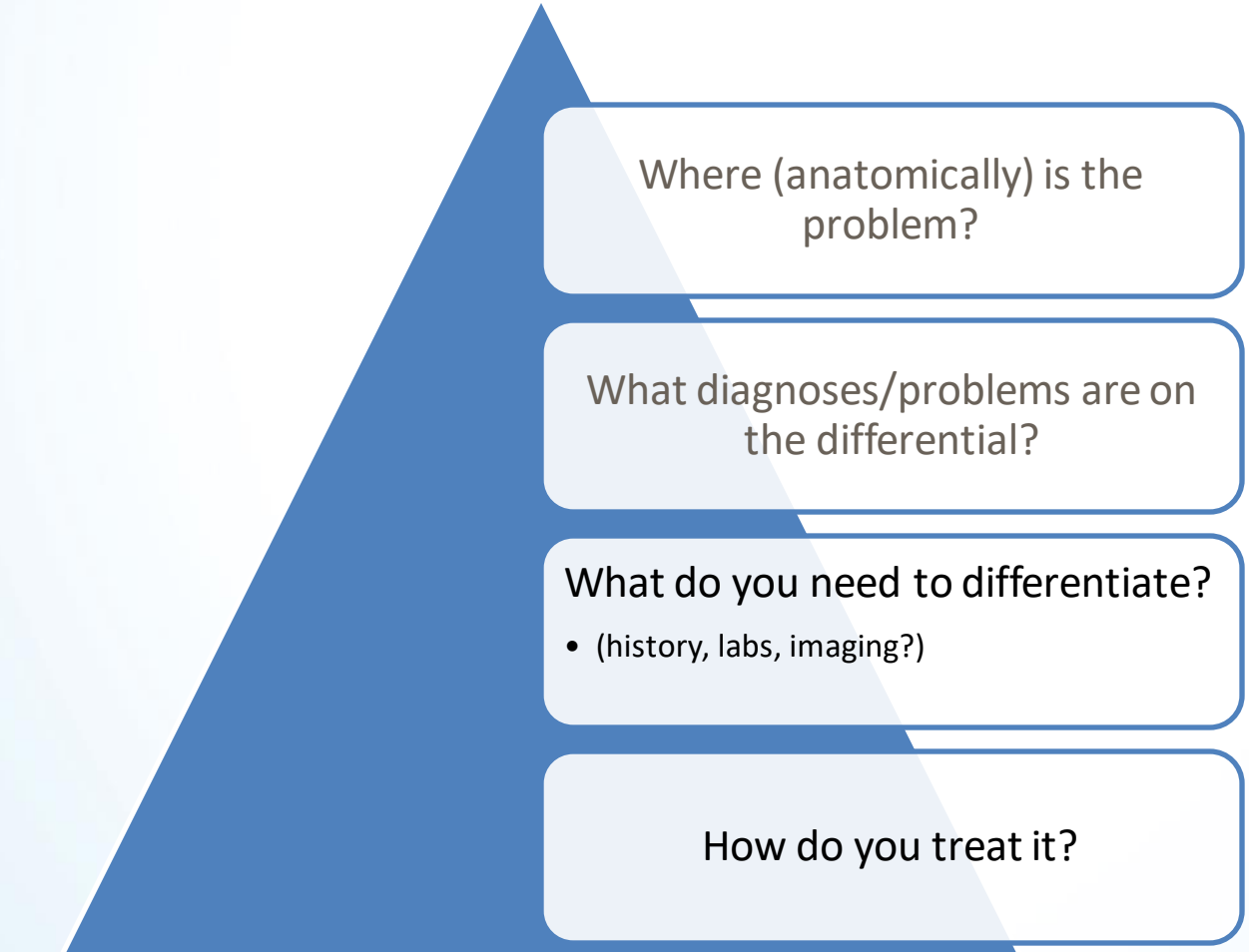
Signs/symptoms:

- Cough, wheeze
- SOB, chest tightness/pain
- Prolonged expiration

Pediatric Asthma Score does not always reflect severity of illness in adolescents

Pediatric Asthma Score (modified)	Mild (5-7)	Moderate (8-11)	Severe (12-15)
	1	2	3
Respiratory Rate 1 to 3 years 4 to 5 years 6 to 12 years Older than 12 years	 40 or less 30 or less 26 or less 23 or less	 41 to 45 31 to 35 27 to 30 24 to 27	 46 or greater 36 or greater 31 or greater 28 or greater
Oxygen Requirements	Greater than 90% on room air	85% to 90% on room air	Less than 85% on room air OR no room air challenge done while on O_2
Auscultation	Normal breath sounds to end-expiratory wheeze only	Expiratory wheezing	Inspiratory and expiratory wheezing to diminished breath sounds or poor aeration
Retractions	Zero to one site	Two sites	Three or more sites
Dyspnea	Speaks in sentences, coos and babbles	Speaks in partial sentences, short cry	Speaks in single word/short phrases/grunting

Step by Step Approach



Treatment

AgileMD | Asthma Exacerbation Management

MILD Initial Pediatric Asthma Score 5-7

Order Bundle

- albuterol HFA (up to 3 doses as needed)
  - Less than or equal to 20kg = 4 puffs
  - Greater than 20kg = 8 puffs
- dexAMETHasone tablet (0.6mg/kg, max 16mg)
- Relabel albuterol HFA
- Asthma Teaching
- Asthma Action Plan

Observe in the ED for 1 hour if 3 doses of Albuterol are administered

MODERATE Initial Pediatric Asthma Score 8-11
SEVERE Initial Pediatric Asthma Score 12-15

Order Bundle

- albuterol-ipratropium nebulizer (3 doses)
- dexAMETHasone tablet (0.6mg/kg, max 16mg)
- Continuous albuterol (at AMC & NOC includes intermittent albuterol every 2 hours)
- Bronchodilator ED Phase Progression
  - CSH: May advance to continuous
  - AMC/NOC: Continuous to every 2 hours
- Cardiorespiratory Monitoring
- Pulse Oximetry
- Oxygen (keep sats 88% or greater)
- Vital Signs every 1 hour
- Pediatric Asthma Score every 1 hour
- Relabel albuterol inhaler for home use
- Asthma Teaching
- Asthma Action Plan

CRITICAL ASTHMA
No Air movement, Severe distress , Poor respiratory effort
Altered mental status

Critical Asthma Bundle

- albuterol-ipratropium nebulizer (3 doses)
- methylPREDNISolone IV (2mg/kg IV, max 60mg)
- magnesium sulfate IV (40 mg/kg IV, max 2000mg)
- lactated ringers bolus
- Continuous albuterol (at AMC & NOC includes intermittent albuterol every 2 hours)
- Bronchodilator ED Phase Progression
  - CSH: May advance to continuous
  - AMC/NOC: Continuous to every 2 hours
- Start IV
- Cardiorespiratory Monitoring
- Pulse Oximetry
- Oxygen (keep sats 88% or greater)
- Vital Signs every 15 minutes
- Diet - NPO

***Consider increasing albuterol dose by 5mg/hour if poor response to therapy**

Additional Orders	Laboratory Studies
EPINEPHrine IM (dosing)	Renal Function Panel
terbutaline IV (dosing)	Magnesium
BiPAP ICU/ED Ventilated Patient Continuous albuterol (Anschutz only)	Venous Blood Gas (ISTAT VBG)
X-Ray Chest 1 View	

Pediatric Asthma Score 5-7
Perform Pediatric Asthma Score (PAS)
Most recent Pediatric Asthma Score

Observation

- 1 hour after 3 albuterol/ipratropium nebs
- 2 hours after stopping continuous albuterol AND/OR magnesium administration
- Give 4-8 puffs of albuterol HFA prior to discharge

for RT/RN

- If intermittent albuterol order has been placed, give albuterol HFA with assessment every 2 hours while in ED
  - If intermittent albuterol order has NOT been placed, contact provider

Consider Discharge Planning

Improved after observation

Pediatric Asthma Score 8 and above

Give Magnesium if not already given after 1 hour on continuous albuterol

Start IV
magnesium sulfate IV
lactated ringers bolus

- Place patient on continuous albuterol & assess every hour
- Consider increasing albuterol dose by 5mg/hour, if patient remains at PAS of 8 despite continuous albuterol and magnesium (modify current orders)

Admit
SpO2 less than 90% on room air.
Requires continuous albuterol for over 1 hour or requiring every 2 hours albuterol

Inpatient Unit

Normal mental status

- Requiring every 2 hour albuterol
- Continuous albuterol for over 1 hour (**Does not apply to *Colorado Springs Hospital***)

Weight	Dose
Less than or equal to 20 kg	10 mg/hr
Greater than 20 kg	15 mg/hr

- NOC sites--2 hours ED observation after Magnesium administration
- Anschutz-- 1 hour ED observation after Magnesium administration

Intensive Care Unit

- Change in mental status
- Impending respiratory failure
- Non invasive ventilation use
- Continuous albuterol requirements below (*except COS--all patient on* continuous *albuterol require PICU admission*)

Weight	Dose
Less than or equal to 20 kg	15 mg/hr and greater
Greater than 20 kg	20 mg/hr and greater

Exam technique matters!

Tricks to elicit deep breaths:

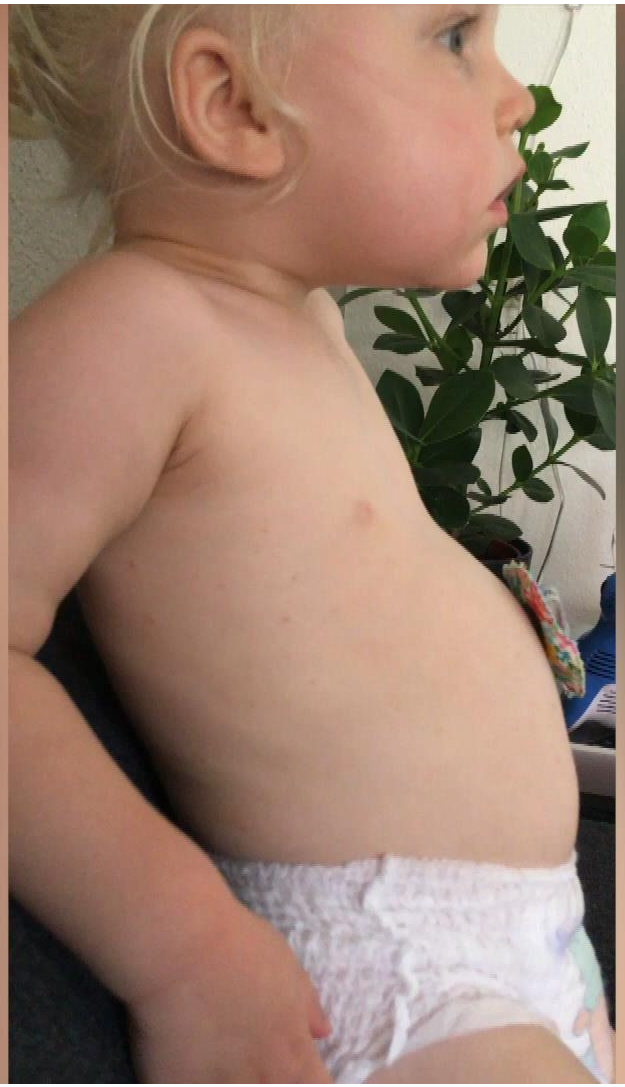
1. Wake them up!
2. Blow out candles
3. Make tissue dance
4. Ask them a question

Impending respiratory failure!

- Work of breathing WITH minimal air movement
- Sitting up/tripoding/can't lie supine
- Can’t speak in even short sentences
- Pulsus paradoxus (drop in SBP >20mmHg for peds during inspiration)
- PaCo2 >42mmHg
- Drop in peak expiratory flow (PEF) of >25%

Case #3

Rapid breathing



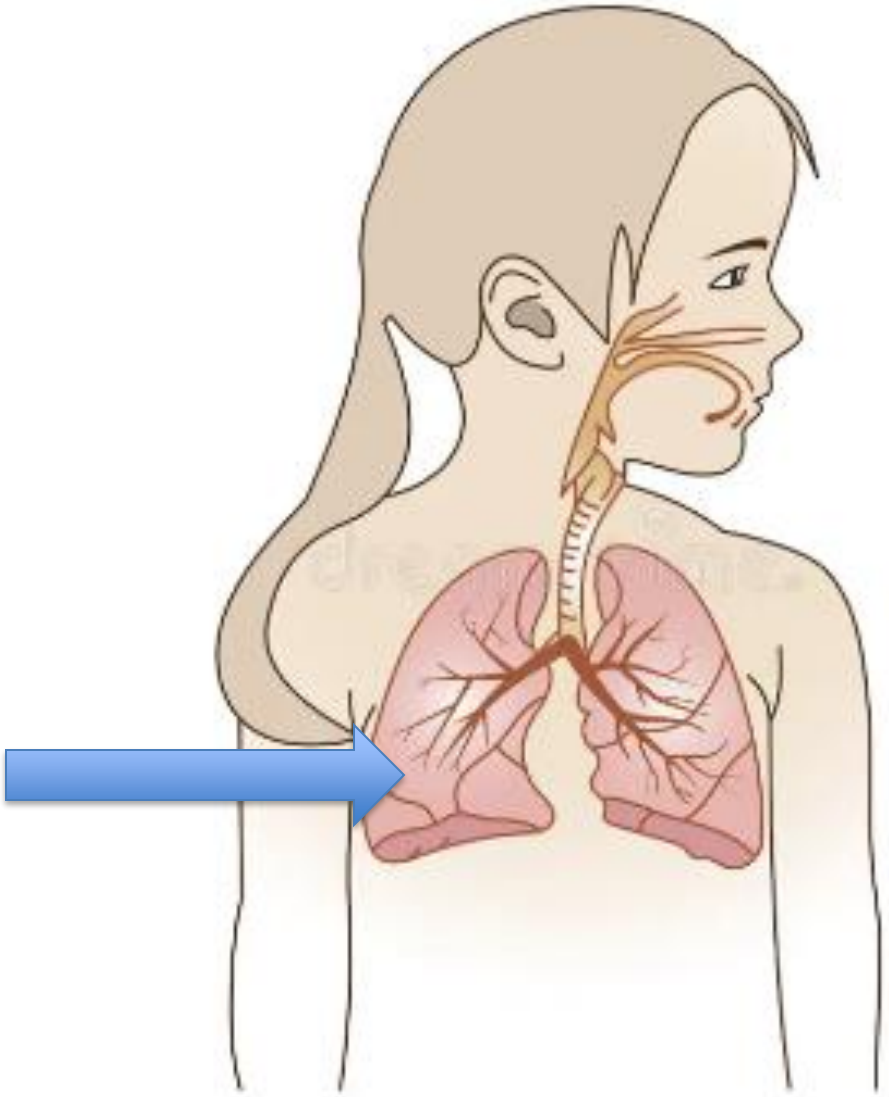
Retractions of the muscles in the chest area and the muscles between the ribs

RSV-PN

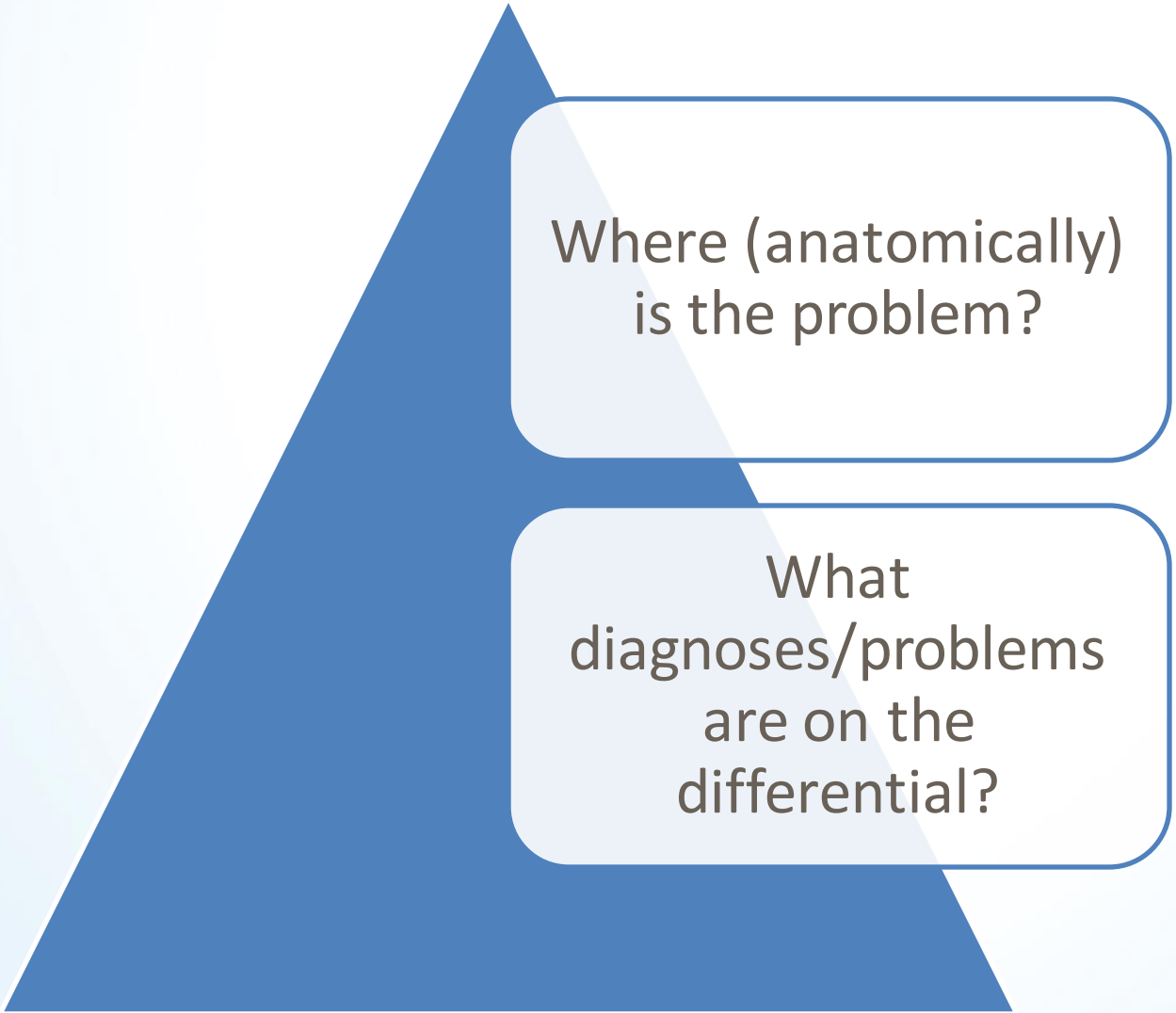
Step by Step Approach

Where (anatomically) is the problem?

Lower Airway



Step by Step Approach



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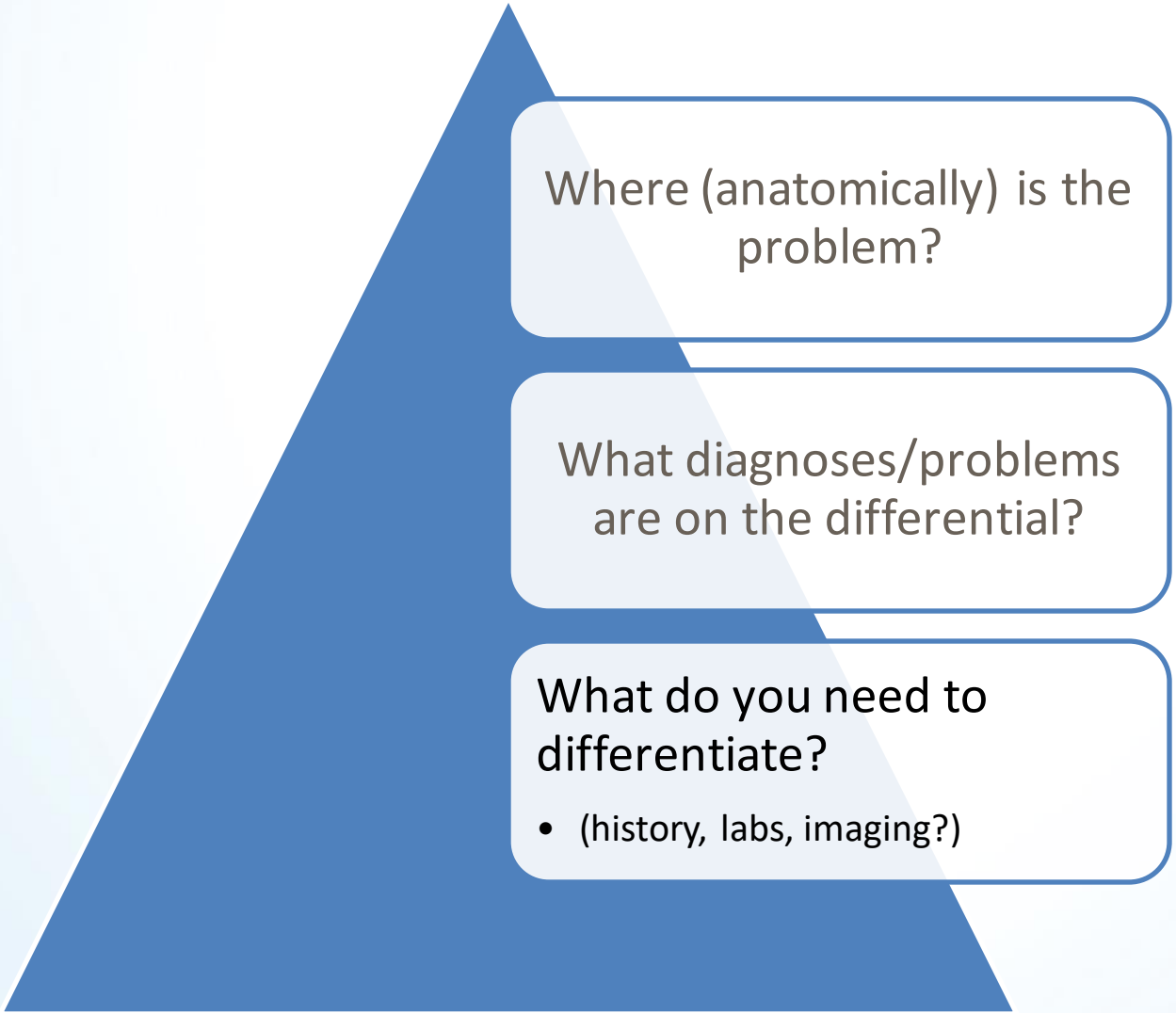

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Bronchiolitis

What is the problem?

Virus causes inflammation of bronchioles (bronchiolITIS). Mucus collects in these airways, impairing gas exchange into and out of lungs.

How do we make diagnosis?

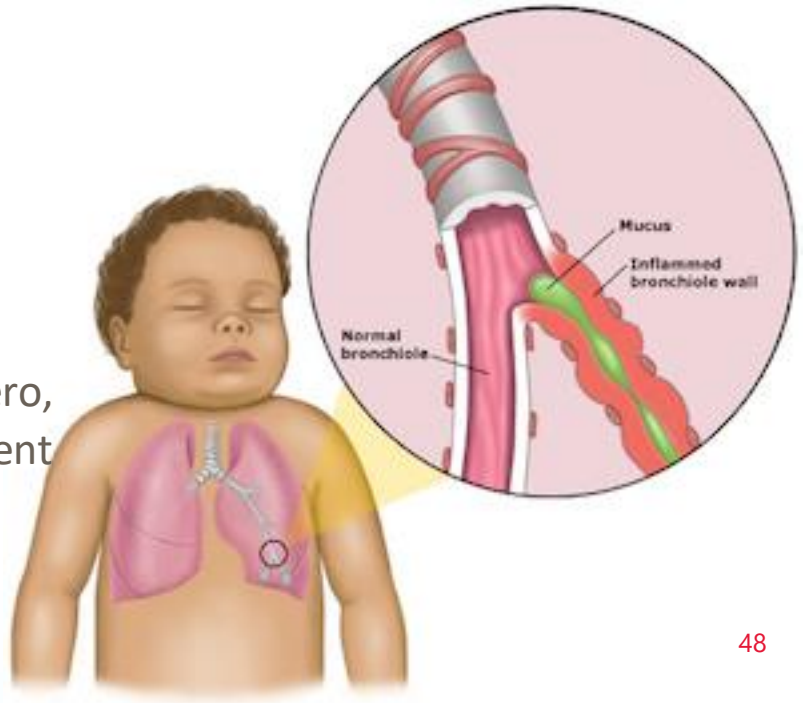
Clinical diagnosis—NO TEST NEEDED

CXR-

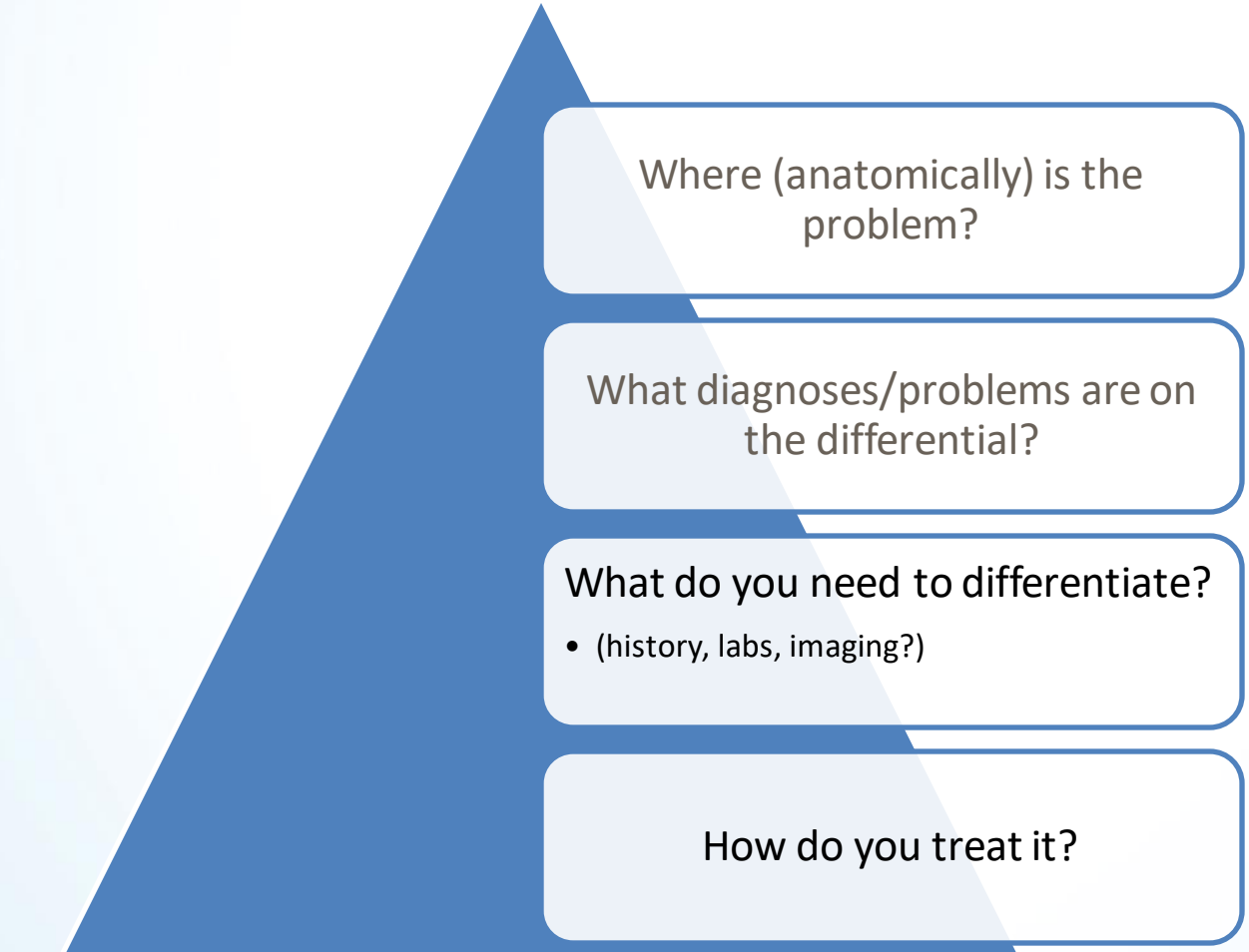
- Unlikely to be helpful
- Charge: ~$450

Viral testing (aka RPP)

- Lots of viruses can cause it (RSV, rhino/entero, COVID, hMPV) but does NOT affect management
- $$$$ (upwards of $750)



Step by Step Approach



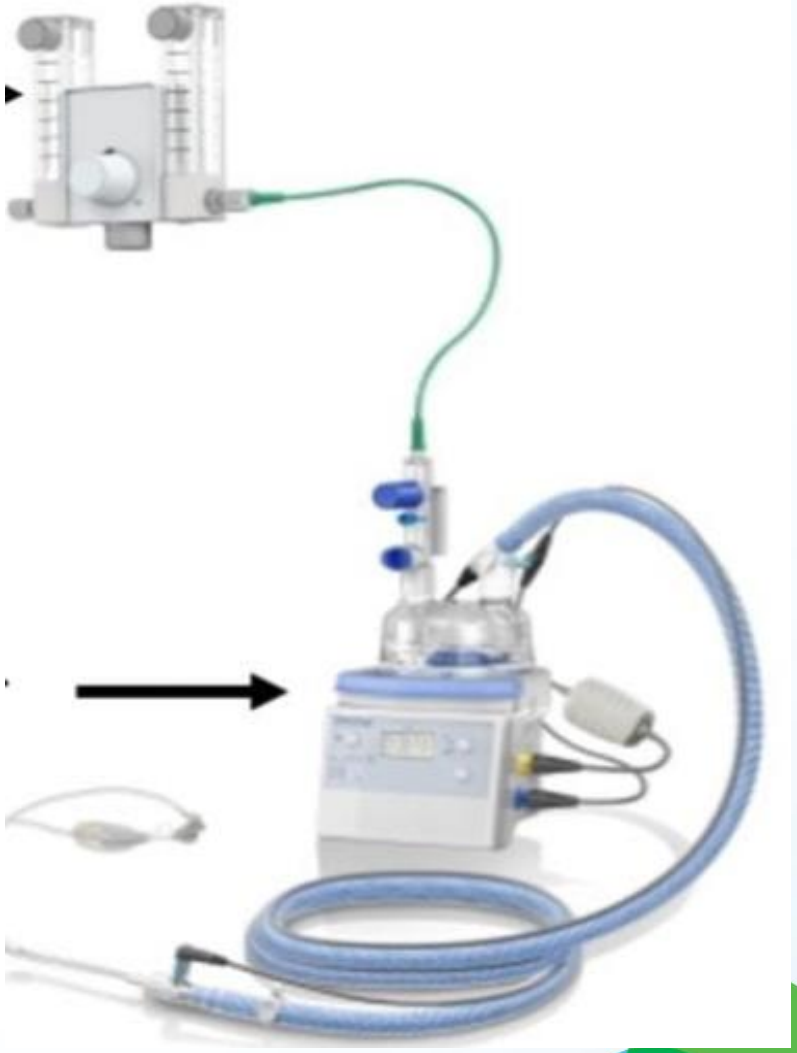
Bronchiolitis Management

- SUCTION, SUCTION, SUCTION!
- Supplemental oxygen for hypoxia and/or WOB
  - LFNC preferred over facemask
- Hydrate? PO vs IV vs NG
- SUCTION AGAIN!
- Additional respiratory support options
  - HHFNC
  - NIPPV
  - Intubation

Heated high flow nasal cannula

Aka "Vapotherm" or "Optiflow" after two main manufacturers

Allows for titration of gas flow (in liters per minute) as well as percent FiO2 (from 21%-100%)



How does HHFNC work

Summary of Actions:

Dead space washout	Reduce dead space making minute ventilation more efficient
Reduce inspiratory work of breathing	Exceed inspiratory flow thus eliminating nasal resistance
Improved lung Mechanics	Warmed, humidified gas has been shown to improve conductance, lung compliance and lung elasticity
Eliminates metabolic work associated with gas conditiong	Attenuates the energy and water loss associated with conditiong inspiratory gas
Provision of mild distending pressure	Provides positive distending pressure for lung recruitment. It prevents alveolar collapse
Improve secretion mobilisation	Ideal humidification of the inspired gas has been shown to restore muco-cilliary function and reduce symptoms of airway exacerbations

Table adapted from: High Flow Nasal Cannula Therapy in Neonatology (TL Miller 2013).

Network of care HHFNC policy

Age	Stay in NOC?	Cannula Size	Initiation Rate	Max Flow Rate
30d to <3 mon	No	Neonatal	4 LPM	8 LPM
>/= 3 mo to 12mo	Yes, if gest age >34weeks	Infant/Pediatric (dep on nare size)	6 LPM	8 LPM
>/= 13 mo to 24 mo	Yes	Pediatric	6 LPM	10 LPM
>/= 24 mo to 5 yrs	Yes	Pediatric	8 LPM	12 LPM
>5 years	Yes	Pediatric/Adult (dep on nare size)	8 LPM	16 LPM

High Flow Nasal Cannula (HFNC) North Campus and South Campus Algorithm ATTACHMENT v.1 (navexone.com)

Appropriately sized nasal cannula should be selected according to the patient's age and/or weight. Confirm that cannula does not fully occlude nares per manufacturer's recommendations.

1) Too small or too large of cannula may lead to pressure injury and changes in expected FiO2 delivery.

If not improved on HHFNC, start BiPap

- Provides distending pressure to prevent alveolar collapse
- PIP helps overcome airway resistance
- May decrease need for intubation (data mixed)
- May require sedation
- In general 12-14 (PIP)/6 (PEEP) is a good starting point

Bronchiolitis ---> asthma?

James KM, Gebretsadik T, Escobar GJ, Wu P, Carroll KN, Li SX, Walsh EM, Mitchel EF, Sloan C, Hartert TV. Risk of childhood asthma following infant bronchiolitis during the respiratory syncytial virus season. J Allergy Clin Immunol. 2013 Jul;132(1):227-9. doi: 10.1016/j.jaci.2013.01.009. Epub 2013 Feb 16. PMID: 23419541; PMCID: PMC3677032.

Relative risk for development of asthma after bronchiolitis is 20-60%
highest risk for more severe illness (i.e. PICU/NICU stay)

Subbarao P, Mandhane PJ, Sears MR. Asthma: epidemiology, etiology and risk factors. CMAJ. 2009 Oct 27;181(9):E181-90. doi: 10.1503/cmaj.080612. Epub 2009 Sep 14. PMID: 19752106; PMCID: PMC2764772.

Prevalence of asthma 10-15% in all school age kids

RSV Prevention!

Nirsevimab (aka Beyfortus)

Who: Newborns & infants <1 year of age entering first RSV season or kids <24 months who remain at risk during 2nd RSV season

How: direct administration of monoclonal antibody

Dose: 50mg if </=5kg, 100mg if >5kg

Abrysvo

Who: Pregnant parent between 32 and 36 weeks (need 2 weeks prior to delivery for infant to acquire immunity)

How: vaccine induced maternal antibodies pass transplacentally to fetus

Palivizumab (aka Synigis)

Who: preterm infants <35 weeks GA, immunocompromised, congenital heart disease

How: direct administration of monoclonal antibody

Dose: 15mg/kg monthly

Nirsevimab STRONGLY preferred for all infants over palivizumab given better efficacy, longer half life (~2 months vs <1 month) and one time dosing.

Case #4

2 year old "not breathing"

Floppy and dusky child

Was playing alone in other room, not breathing when parents came in to check.

Step by Step Approach

In a code scenario, start with ABCs...

- Pulse check
- Open mouth and look for FB
- Position airway "sniffing" position, roll under shoulders
- PPV
  - Rate 1 breath every 2-3 seconds
- Chest rise? Resistance?

2 yo “Not breathing”

60 seconds after starting BVM:

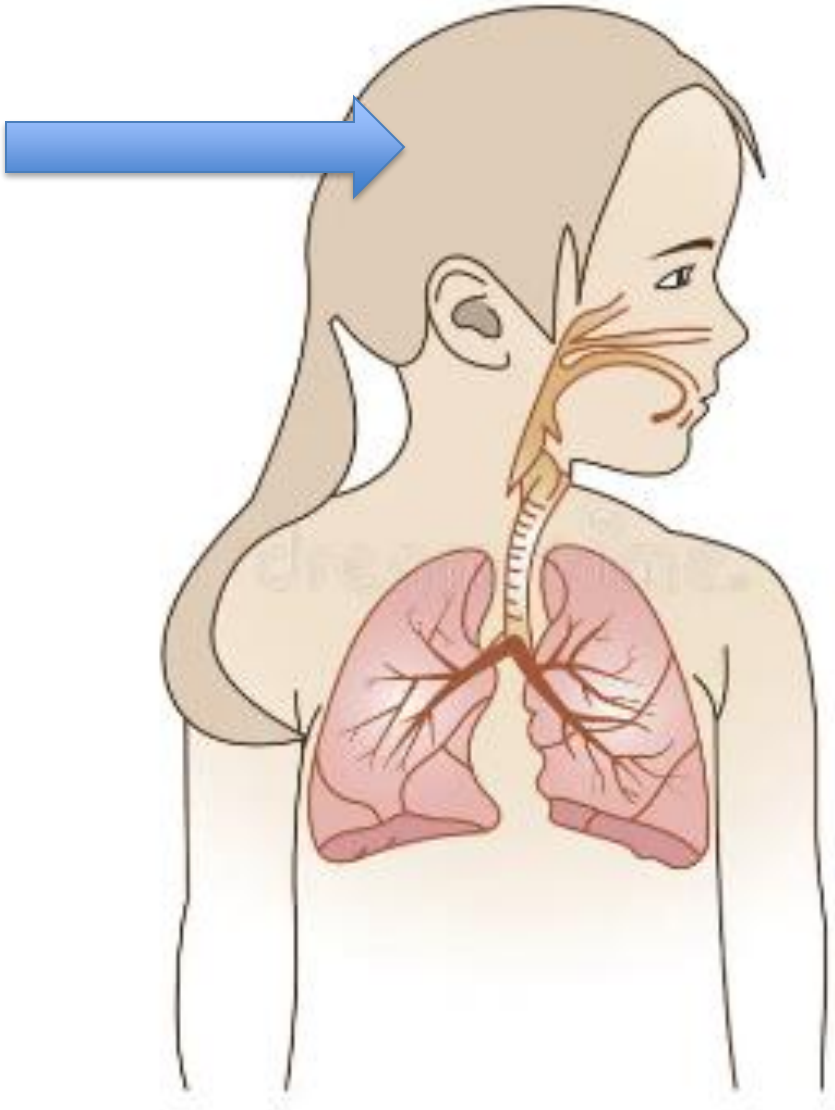
- Improved color;
- Stronger brachial pulses
- Vital signs: Pulse Ox 90% HR: 100
- But still no spontaneous respiratory effort

Now what?

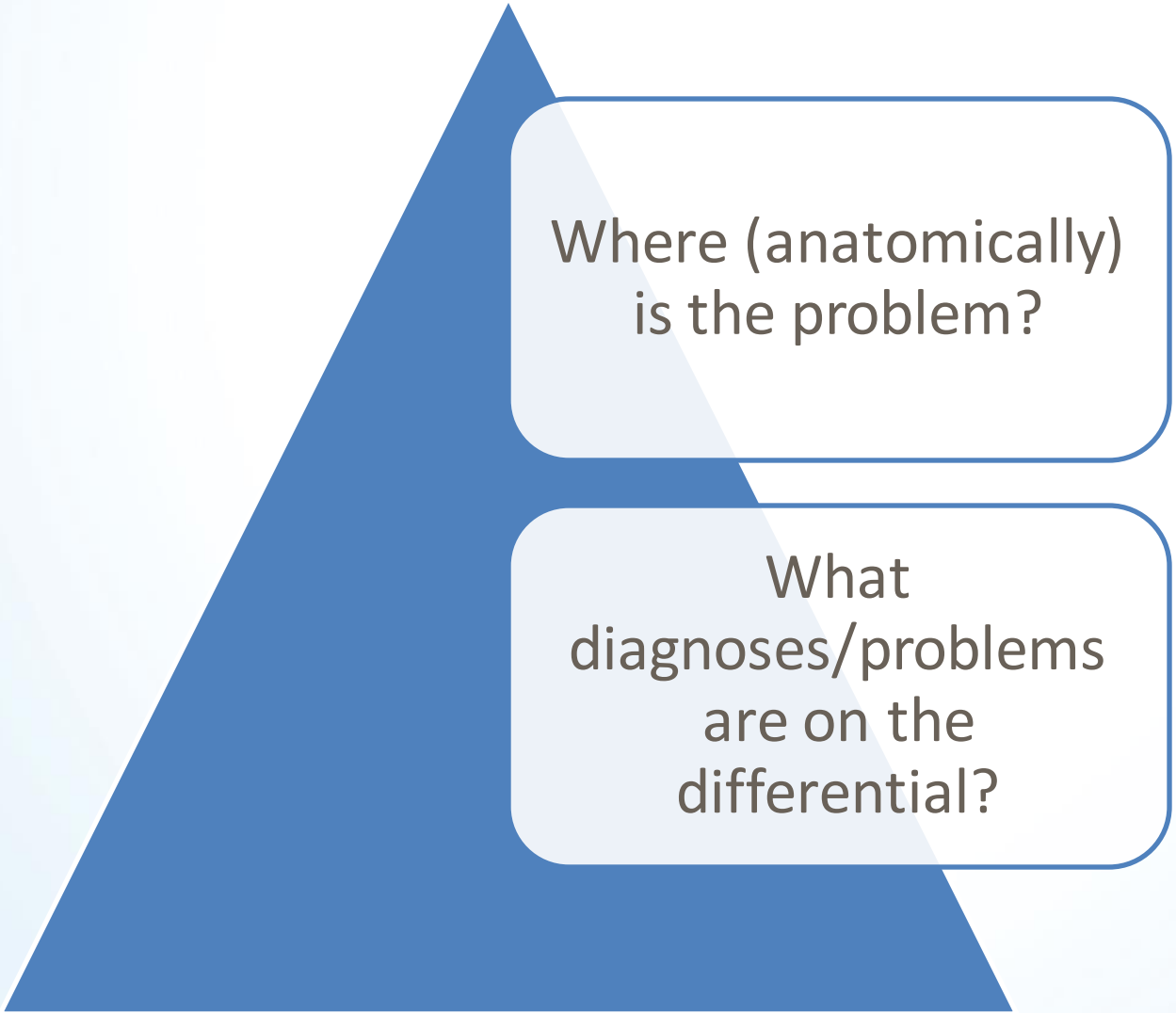
Step by Step Approach

Where (anatomically) is the problem?

CNS regulation of breathing



Step by Step Approach



CNS control of breathing

Trauma

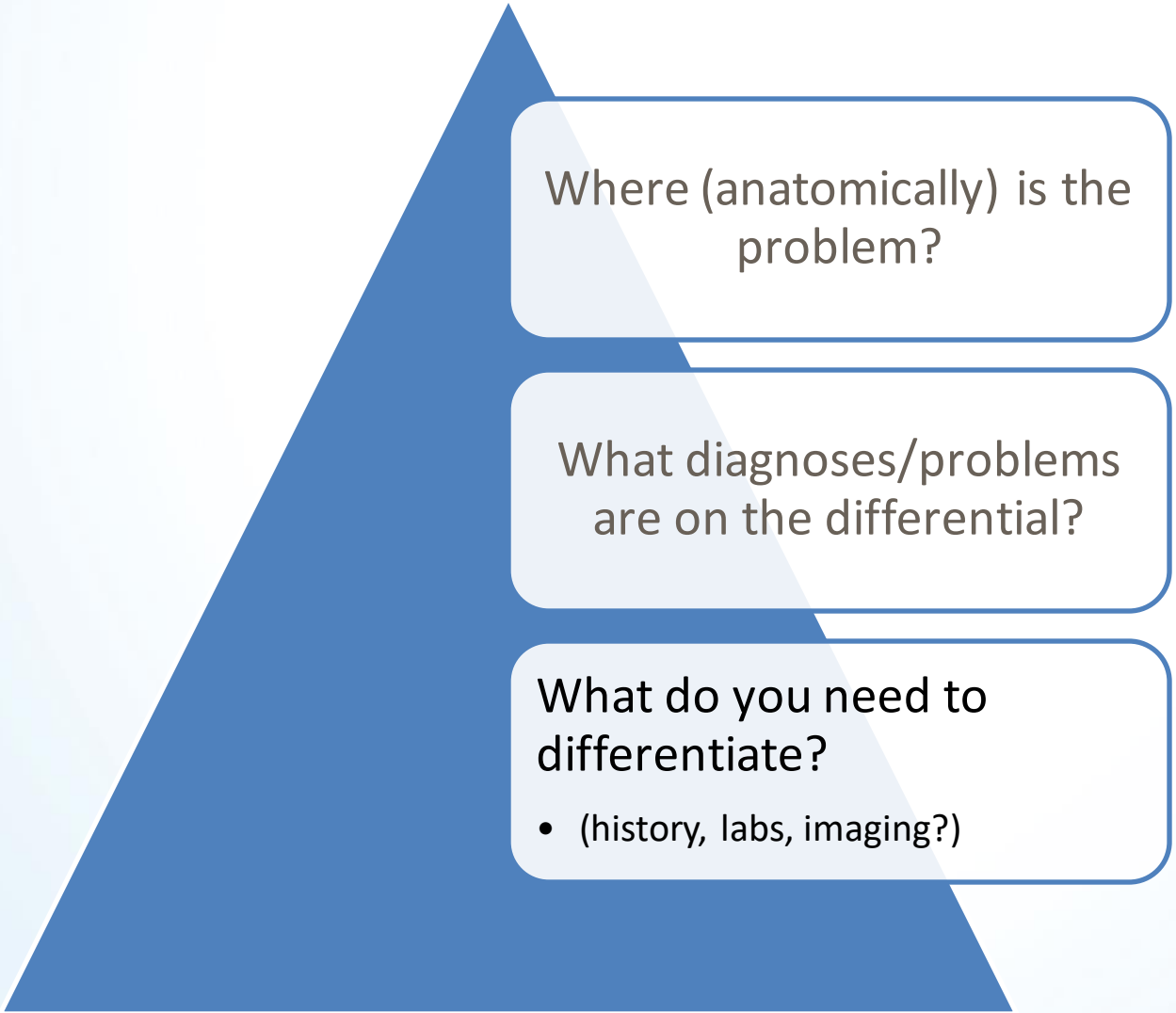
Drug/medication overdose

(opioids, benzodiazepines, alcohol, barbiturates)

Seizure

Increased ICP (obstructive hydrocephalus/shunt malfunction, mass, etc)

Step by Step Approach



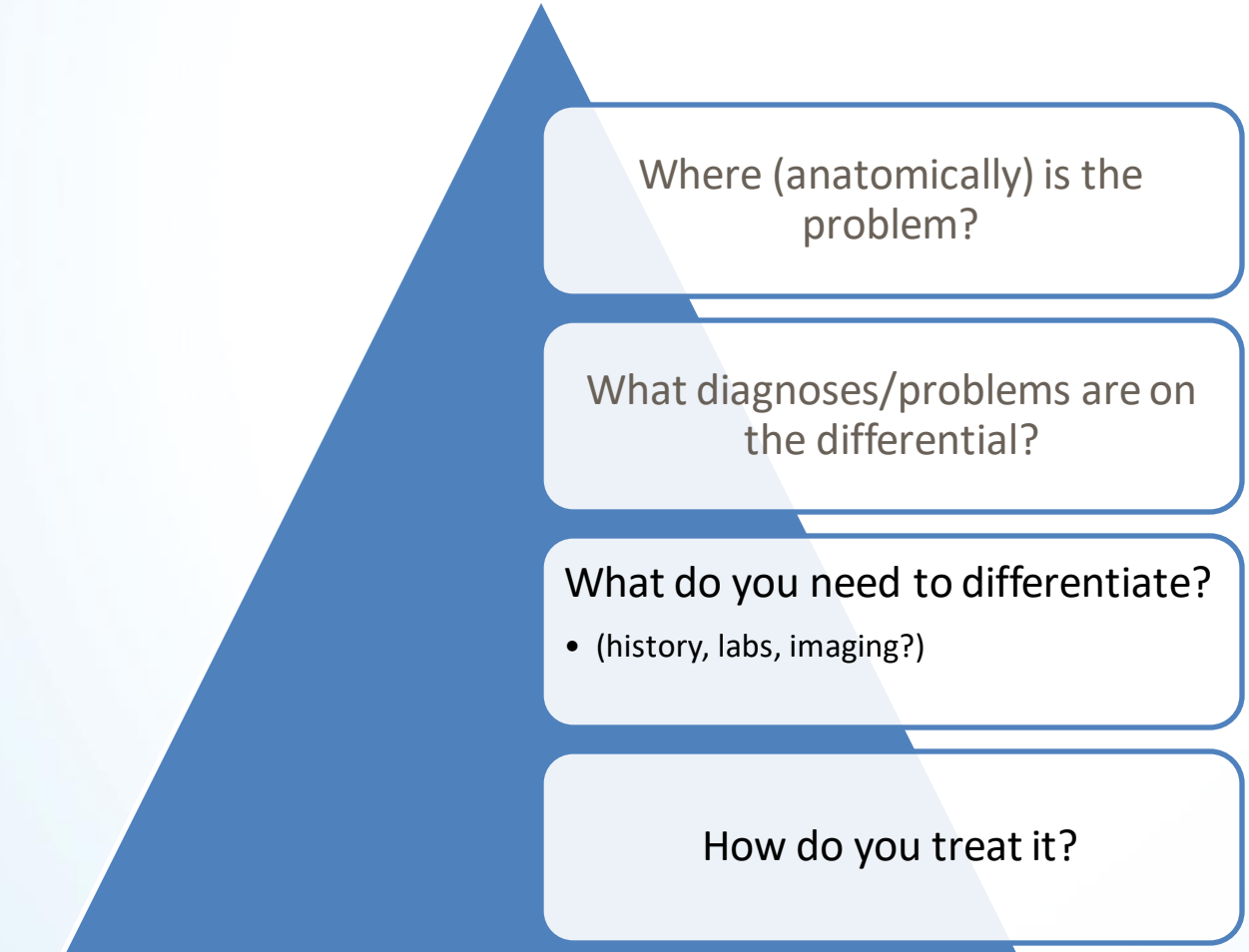
Where (anatomically) is the problem?

What diagnoses/problems are on the differential?

What do you need to differentiate?

- (history, labs, imaging?)

Step by Step Approach



2 yo “Not breathing”

If apneic and no known reason, try Naloxone

Minimal side effects (dizziness, acute withdrawal if chronic opioid use)

Bug Watch

Content Editors: Samuel R Dominguez, MD, PhD (samuel.dominguez@childrenscolorado.org) &
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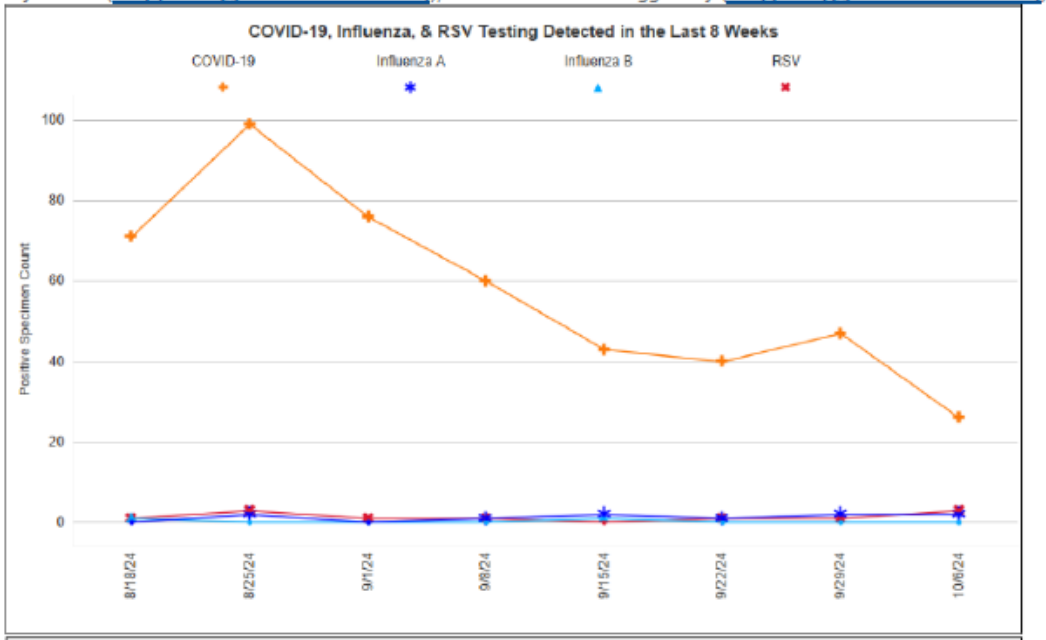

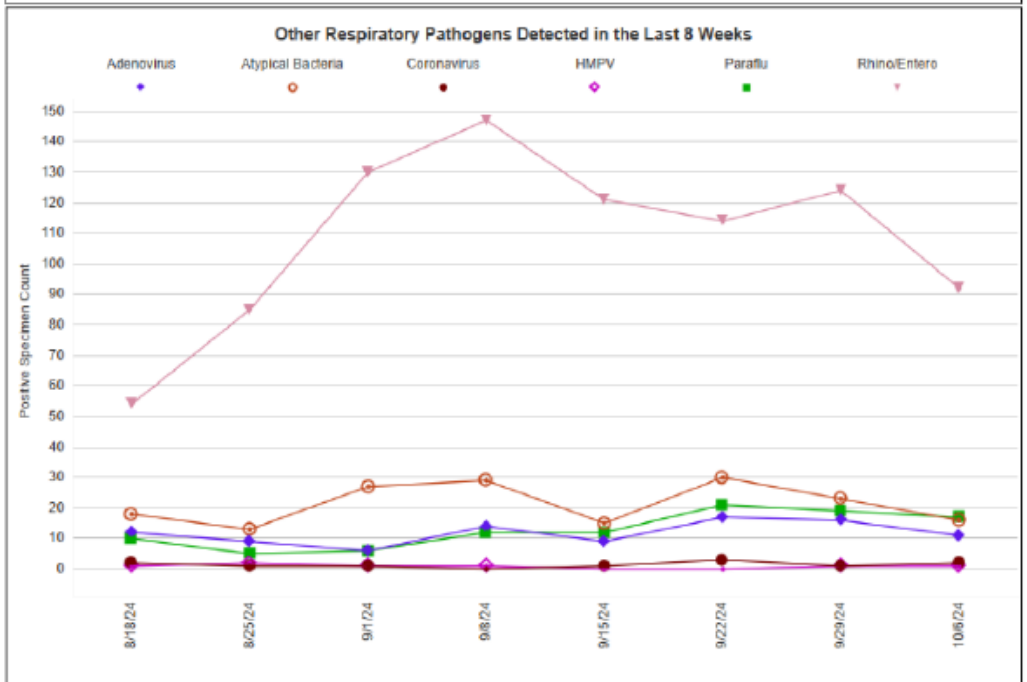

Steroids <5 yrs old?

Should Wheezing Preschool Children Get Oral Corticosteroids?

James A. Feinstein, MD, MPH, reviewing Lee B et al. Lancet Respir Med 2024 Jun Makrinioti H. Lancet Respir Med 2024 Jun

Oral prednisolone during hospitalization reduced clinical symptoms and shortened hospital length of stay in select groups.

For preschool children (age range, 1–5 years) who present with wheezing in the acute care setting, clinicians often must make challenging decisions on whether to treat them with oral corticosteroids. Placebo-controlled trials have yielded discordant results about the effectiveness of steroids, which has discouraged a unified treatment approach.

In this meta-analysis, researchers analyzed individual participant–level data from 7 placebo-controlled, randomized trials. A total of 1728 preschool children who presented to the hospital with wheezing received oral prednisolone (the steroid used in each of the trials) or placebo. Results for children who received oral prednisolone, versus those who received placebo, were as follows:

- Meaningfully lower wheezing severity score at 4 hours; greatest difference for children with moderate-to-severe wheezing (compared with the subgroup who had mild wheezing)
- Shorter hospital length of stay (by 3 hours); greatest difference for children with previous wheezing or diagnosed asthma
- A higher, but nonsignificant, risk for vomiting

COMMENT

Even 15 years into practice, I still find the decision vexing about whether to treat a wheezing child with steroids: Will steroids help? Or am I unnecessarily exposing the child to side effects and contributing to overuse? These meta-analysis results add parameters to the clinical instincts many of us have: For a child with moderate-to-severe wheezing or a history of wheezing or asthma, steroids reduce clinical symptoms and shorten subsequent length of stay.

Non-invasive pathogen identification using microbial cell-free DNA

Diagnostic Microbiology and Infectious Disease
Volume 110, Issue 2, October 2024, 116468

Pathogen kinetics and detection by next-generation sequencing in pediatric complicated pneumonia

Katherine M. Rodriguez [a b], Katherine L. Perofsky [a b], Nanda Ramchandar [a b c], Jennifer Foley [b], Nidhi Shah [d], Marta Mangifesta [d], Robert Schlaberg [d], Lauge Farnaes [e], Rita Czako Stinnett [d], Nicole G. Coufal [a b]

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Abstract

Pediatric pneumonia can be severe and result in empyema. Next-generation sequencing (NGS) may broadly detect pathogens though, optimal timing and impact of sample type on diagnostic yield is unknown. This is a prospective, single-center pilot study of children aged 3 months through 17 years admitted to the PICU with a primary diagnosis of complicated pneumonia. Plasma, endotracheal, nasopharyngeal, and pleural fluid samples were collected at three time points during hospitalization. After nucleic acid extraction, combined libraries were enriched with an NGS enrichment panel kit (RPIP, Illumina), sequenced and quantitative organism detections were analyzed. NGS identified the same bacterial pathogen as traditional testing in all samples, regardless of antibiotic pre-treatment or time collected. Conventional culture methods only identified the pathogen reliably in invasively obtained pleural fluid or endotracheal aspirates. Future application of NGS may allow for non-invasive pathogen detection at a broader range of time points and more targeted antibiotic coverage.

Take Home Points

- Kids have large heads, but small airways
  - Position the airway properly for success
- Figure out where the problem is first!
  - Upper vs lower airway vs central
- It might be mycoplasma
  - Consider testing/treating school age kids
- It might not be the lungs
  - Low threshold to try Narcan for apnea—it won't hurt, and could save your patient's life

THE END

Questions?

Resources

- Clinical Pathways | Children's Hospital Colorado (childrenscolorado.org) (evidence based guidance by clinical topic)
- Children's Hospital of Philadelphia Clinical Pathways https://pathways.chop.edu/pathways-library
- AAP Clinical Practice Guidelines (Meta-analyses and expert consensus)
- Children's Hospital Colorado and Denver Health (firstline.org) (antimicrobial stewardship recommendation app)
- OneCall 720-777-3999—for specialty consults or transfers

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