UNIVERSITATEA DE STAT DE MEDICINĂ ȘI FARMACIE
„NICOLAE TESTEMIȚANU” DIN REPUBLICA MOLDOVA

Basic respiratory syndromes. Upper and lower acute respiratory disorders in children

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Chisinau 2021

Learning objectives

To understand:

- anatomical and physiological features of the respiratory tract in children vs adults
- most frequent sign, symptoms and syndromes of respiratory diseases in children
- examination of children with respiratory diseases
- management of children with upper and lower acute respiratory disorders

Peculiarities of the Respiratory System in Children

Respiratory system

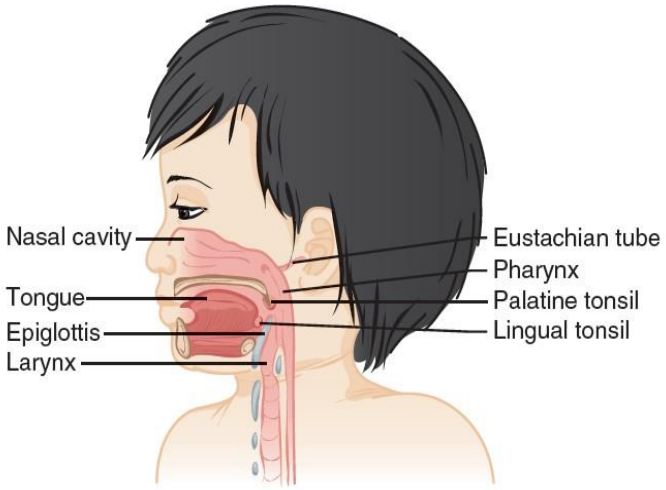


Fig 16.1 Upper airway.

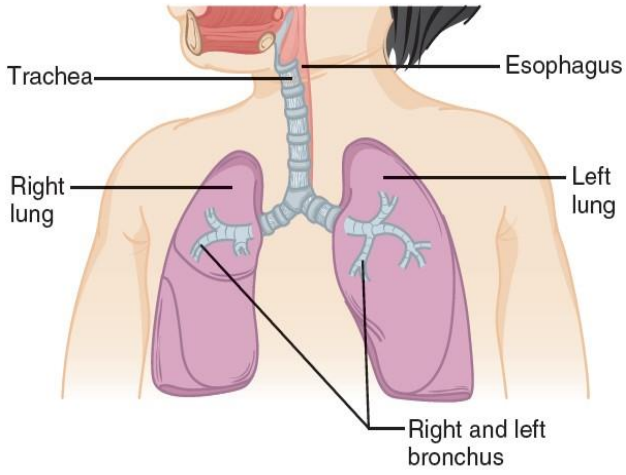


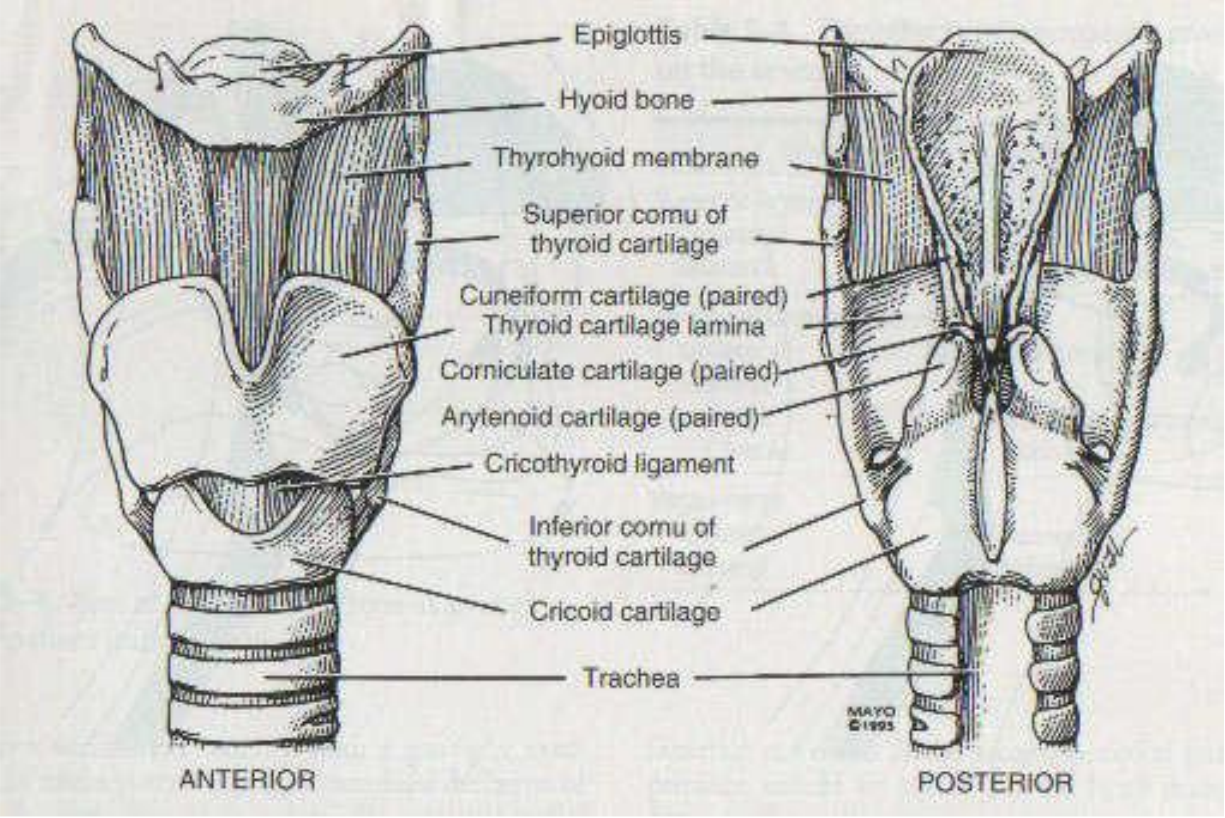
Fig 16.2 Middle and lower airways.

- The **upper airway**, containing the nasopharynx and oropharynx, serves as the pathway for gases exchanged during ventilation, the movement of oxygen into the lungs and carbon dioxide out of the lungs. The larynx divides the upper and lower airways.
- The **lower airways** (trachea, bronchi, and bronchioles) serve as the pathway of gases to and from the alveoli in the lungs.

Respiratory system

Larynx composed of hyoid bone and a series of cartilages:

- Single: thyroid, cricoid, epiglottis
- Paired: arytenoids, corniculates, and cuneiform



Peculiarities of the respiratory system in children

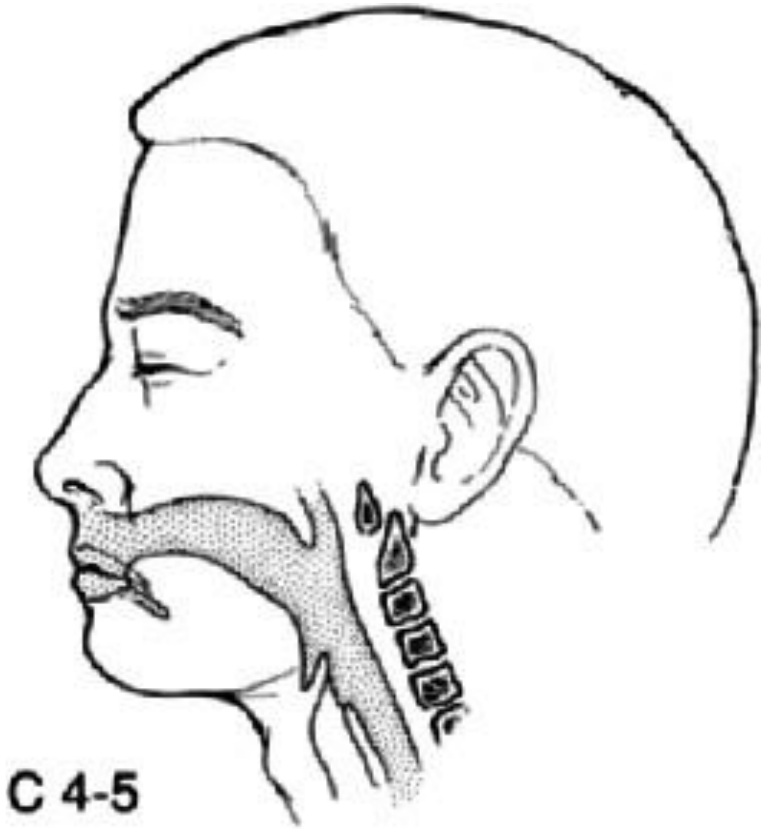
5 Differences between Pediatric and Adult Upper airway:

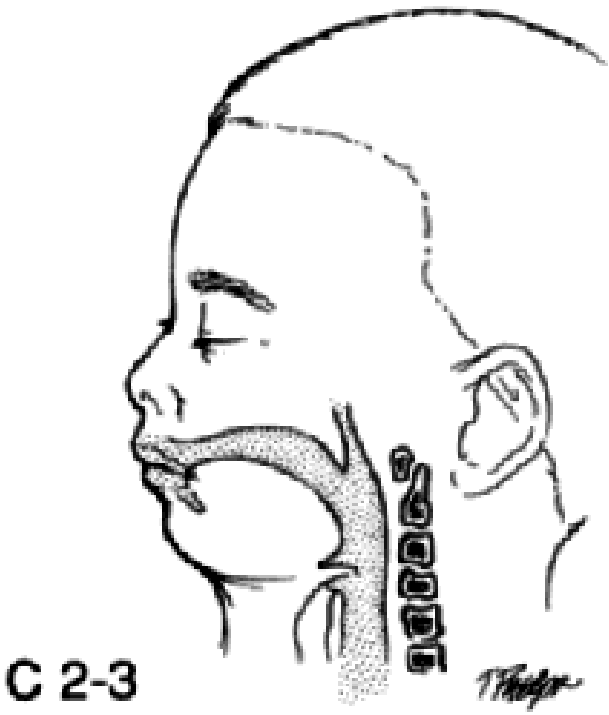
- More rostral larynx
- Relatively larger tongue
- Angled vocal cords
- Differently shaped epiglottis
- Funneled shaped larynx-narrowest part of pediatric airway is cricoid cartilage

Peculiarities of the respiratory system in children

More rostral larynx

- Laryngeal apparatus develops from brachial clefts and descends caudally
- Infant's larynx is higher in neck (C2-3) compared to adult's (C4-5)





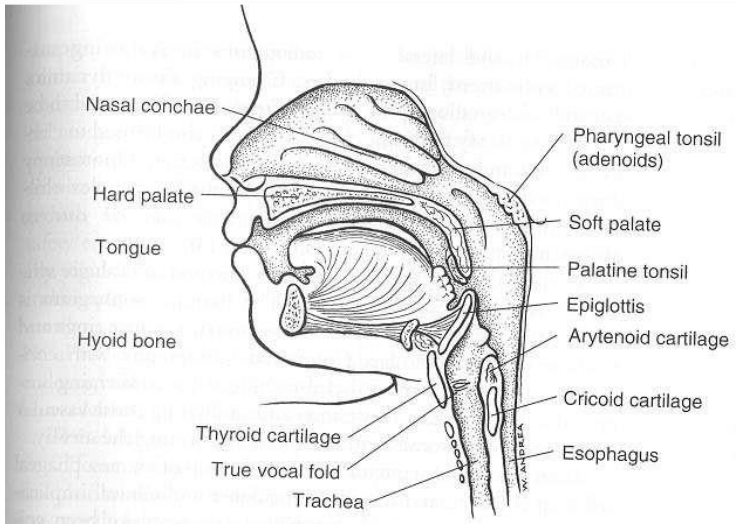
Peculiarities of the respiratory system in children

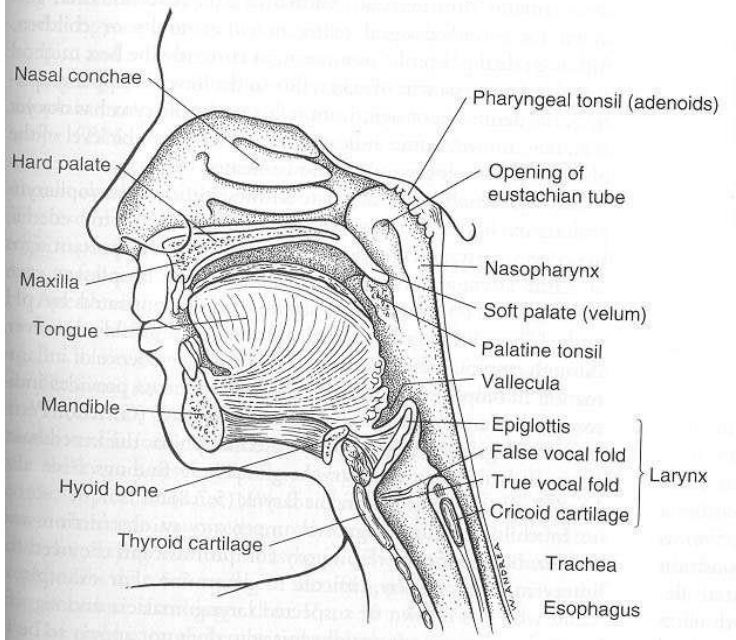
Relatively larger tongue

- Obstructs airway
- Obligate nasal breathers
- Difficult to visualize larynx
- Straight laryngoscope blade completely elevates the epiglottis, preferred for pediatric laryngoscopy

Angled vocal cords

- Infant's vocal cords have more angled attachment to trachea, whereas adult vocal cords are more perpendicular
- Difficulty in nasal intubations where "blindly" placed ETT may easily lodge in anterior commissure rather than in trachea

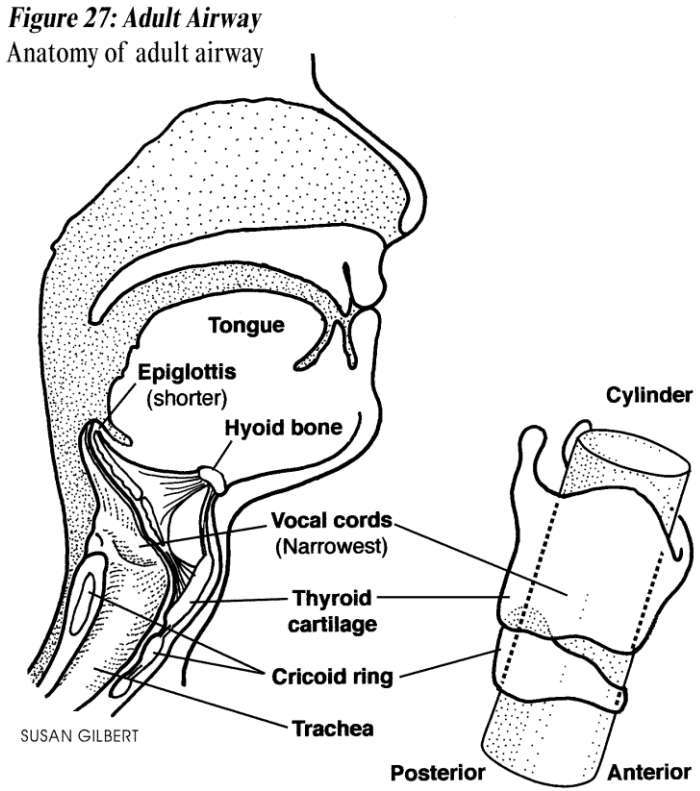


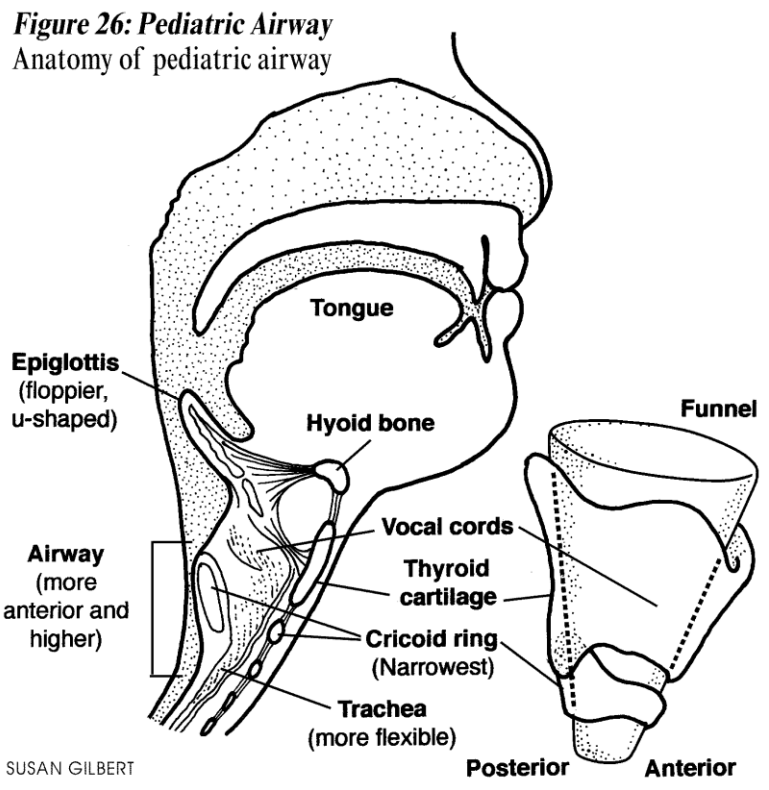


Peculiarities of the respiratory system in children

Differently shaped epiglottis:

- Adult epiglottis broader, axis parallel to trachea
- Infant epiglottis *ohmega* (Ω) shaped and angled away from axis of trachea
- More difficult to lift an infant's epiglottis with laryngoscope blade

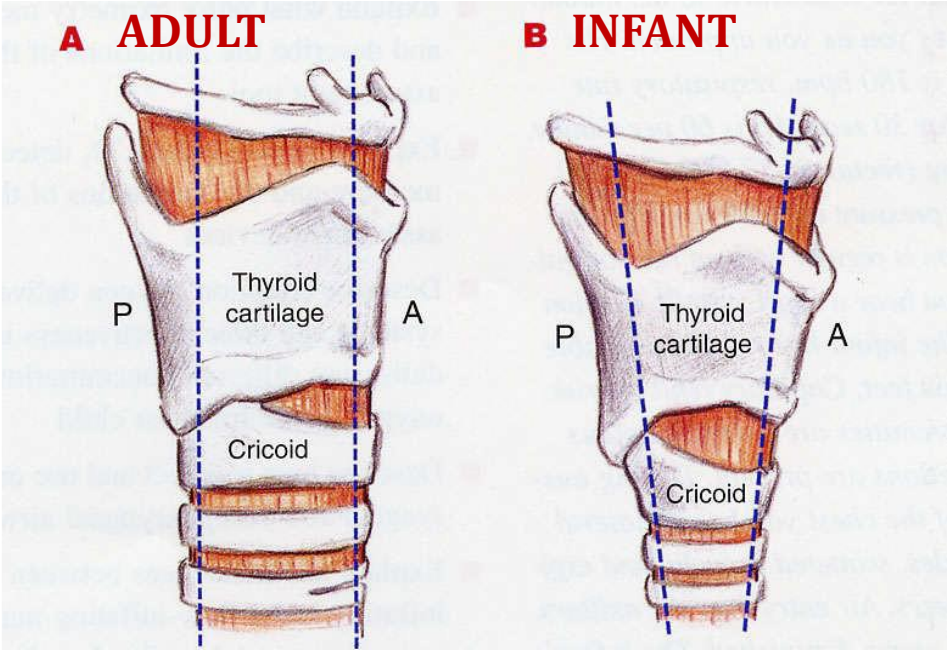




Peculiarities of the respiratory system in children

Funneled shape larynx:

- Narrowest part of infant's larynx is the undeveloped cricoid cartilage, whereas in the adult it is the glottis opening (vocal cord)
- Tight fitting ETT may cause edema and trouble upon extubation
- Uncuffed ETT preferred for patients < 8 years old
- Fully developed cricoid cartilage occurs at 10-12 years of age



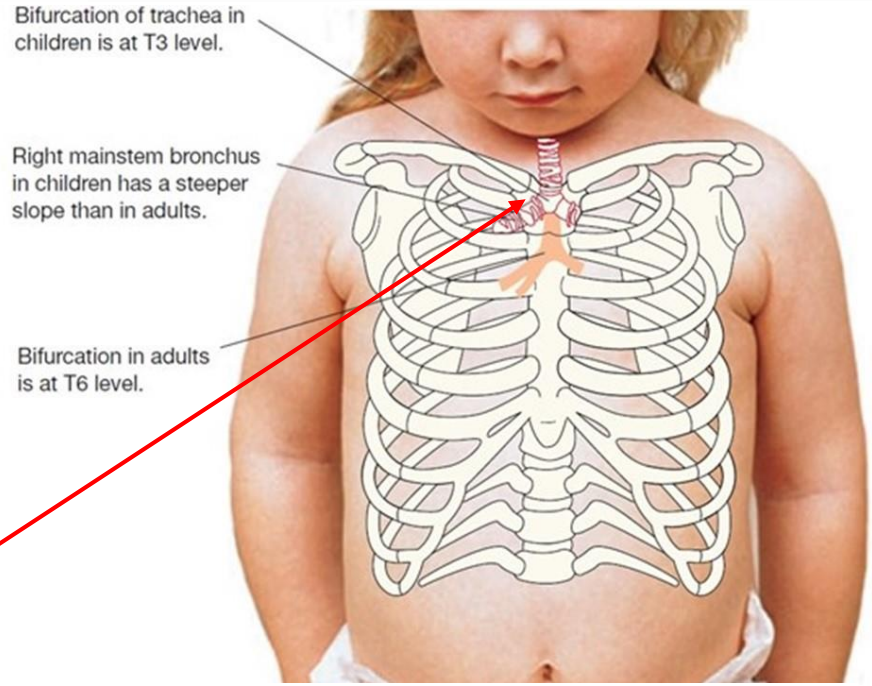
Pediatric Respiratory Physiology

- Extrauterine life not possible until 24-25 weeks of gestation
- Two types of pulmonary epithelial cells: Type I and Type II pneumocytes
  - Type I pneumocytes are flat and form tight junctions that interconnect the interstitium
  - Type II pneumocytes are more numerous, resistant to oxygen toxicity, and are capable of cell division to produce Type I pneumocytes
- Pulmonary surfactant produced by Type II pneumocytes at 24 wks GA
- Sufficient pulmonary surfactant present after 35 wks GA
- Premature infants prone to respiratory distress syndrome (RDS) because of insufficient surfactant
- Alveoli continue developing and increasing in number for the first 5 to 8 years of age, followed by further development in size and complexity

Peculiarities of the respiratory system in children

- The infant's airway diameter is approximately 4 mm (0.16 in.), about the width of a drinking straw, in contrast to the adult's airway diameter of 20 mm (0.8 in.).

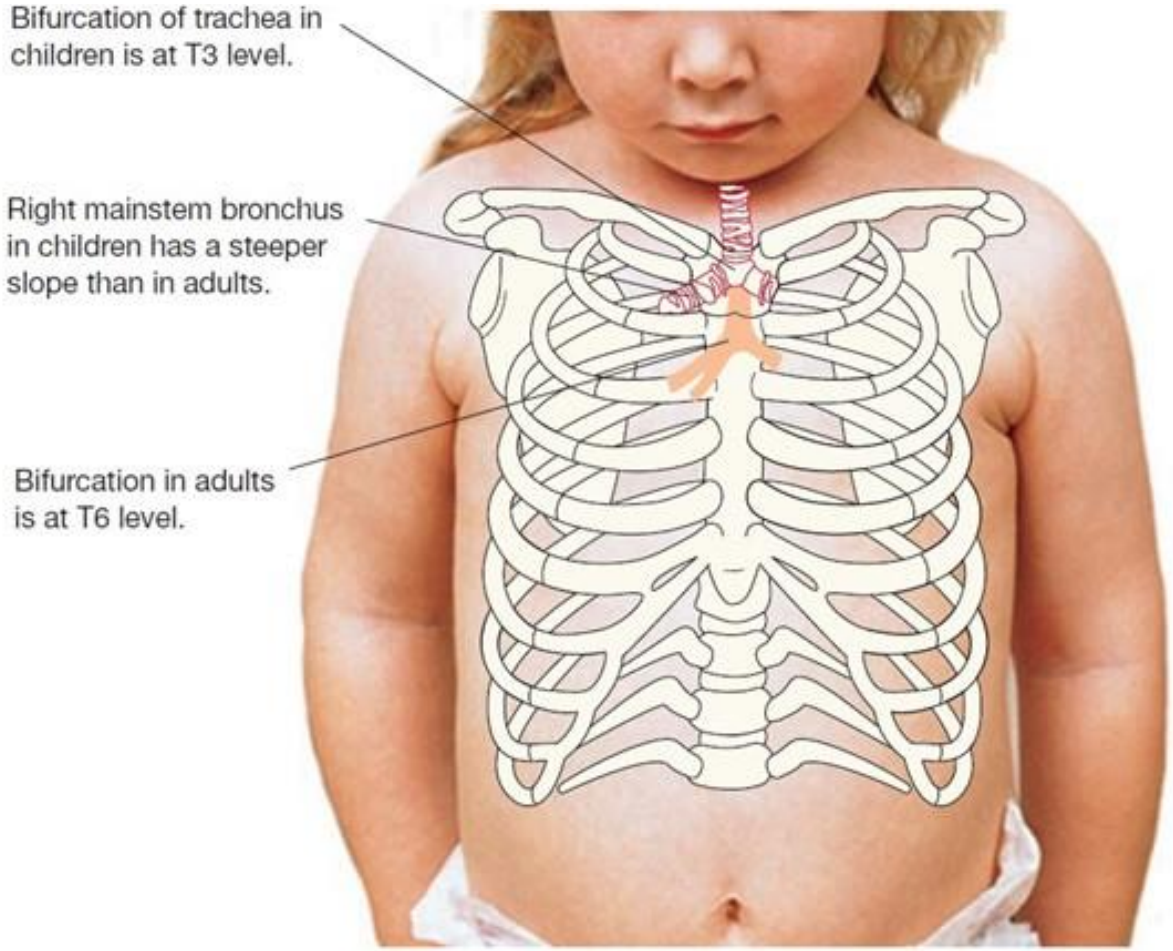
- The trachea primarily increases in length rather than diameter during the first 5 years of life.



- The tracheal division of the right and left bronchi is higher in a child's airway and at a different angle than the adult's.

The child's little finger is a good estimate for the child's tracheal diameter and can be used for a quick assessment of airway size!

Peculiarities of the respiratory system in children



In children, the trachea is shorter and the angle of the right bronchus at bifurcation is more acute than in the adult. When you are resuscitating or suctioning, you must allow for these differences. Do you think that the angle of the right bronchus is significant in foreign-body aspiration? Why?

Peculiarities of the respiratory system in children

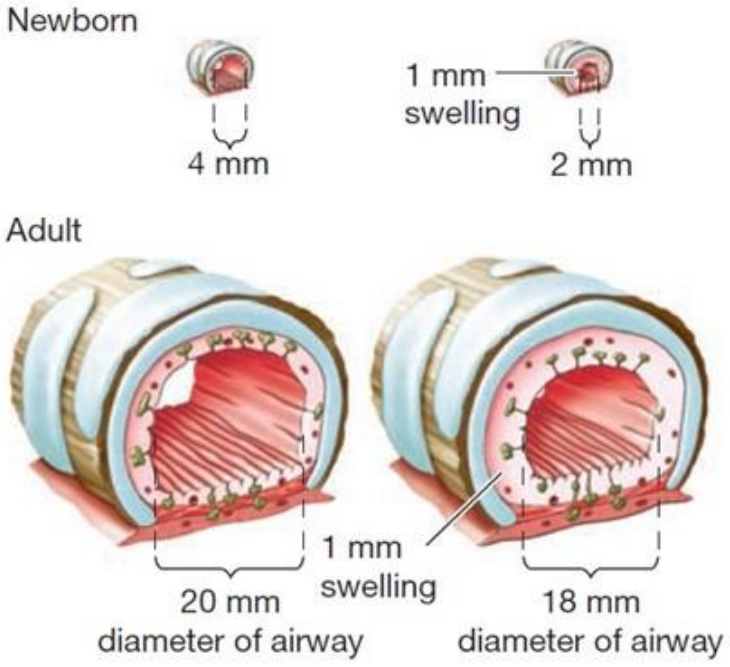
- The cartilage that supports the trachea is more flexible, and the airway may be compressed when the head and neck are flexed toward the chest.
- The child's narrower airway causes a greater increase in **airway resistance** (the effort or force needed to move oxygen through the trachea to the lungs) in any condition causing airway inflammation or edema
- Work of breathing for each kilogram of body weight is similar in infants and adult
- Oxygen consumption of infant (6 ml/kg/min) is twice that of an adult (3 ml/kg/min)

Greater oxygen consumption = increased respiratory rate

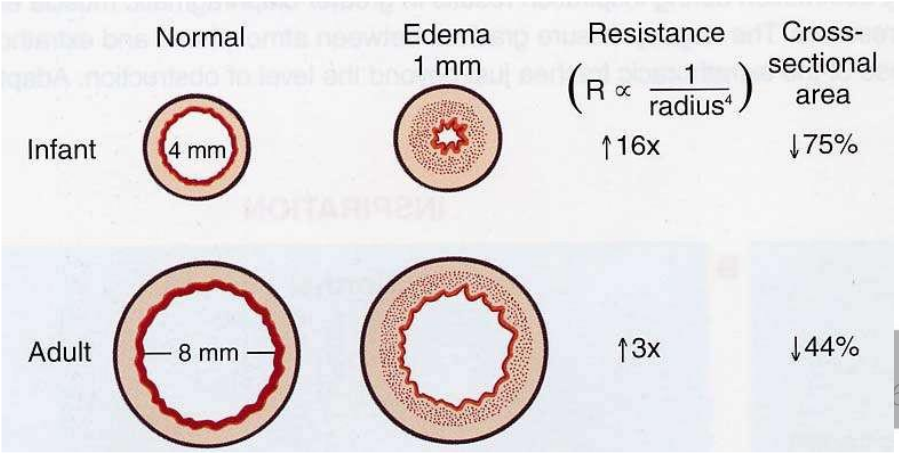
Pediatric Respiratory Physiology

- Tidal volume is relatively fixed due to anatomic structure
- Minute alveolar ventilation is more dependent on increased respiratory rate than on tidal volume
- Lack Type I muscle fibers, fatigue more easily
- Functional residual capacity (FRC) of an awake infant is similar to an adult when normalized to body weight
- Ratio of alveolar minute ventilation to FRC is doubled, under circumstances of hypoxia, apnea or under anesthesia, the infant's FRC is diminished and desaturation occurs more precipitously

Physiology: effect of edema



An infant's airway diameter is approximately 4 mm (0.16 in.), in contrast to the adult's 20–mm (0.8-in.) airway diameter. An inflammatory process in the airway causes swelling that narrows the airway, and airway resistance increases. Note that swelling of 1 mm (0.04 in.) reduces the infant's airway diameter to 2 mm (0.08 in.), but the adult's airway diameter is only narrowed to 18 mm (0.7 in.). Air must move more quickly in the infant's narrowed airway to get the needed amount of air into the lungs. The friction of the quickly moving air against the side of the airway increases airway resistance. The infant must use more effort to breathe and must breathe faster to get adequate oxygen.



If radius is halved, resistance increases 16 x

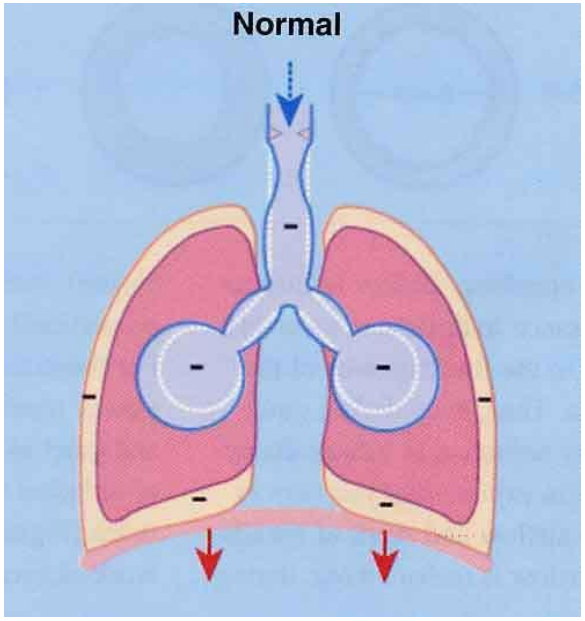
Poiseuille's law

$$R = 8nl/\pi r^4$$

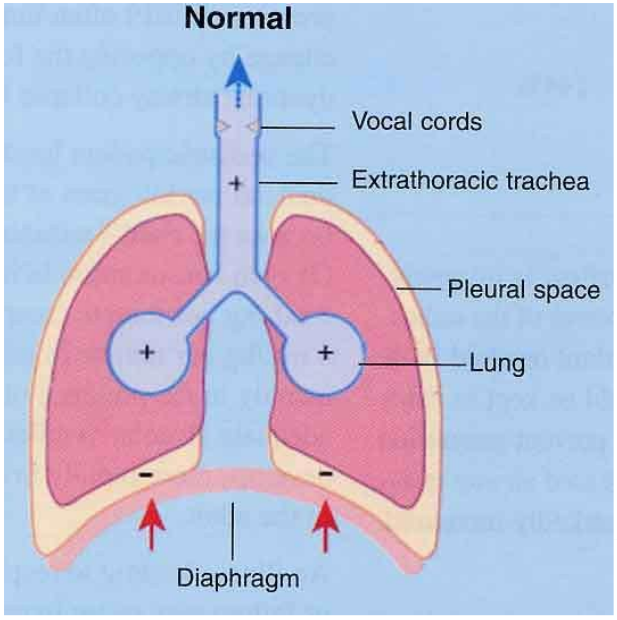
Respiratory physiology

- The intercostal muscles work with the diaphragm to perform the work of breathing. The diaphragm is a muscle that separates the abdominal and thoracic cavity contents. When the diaphragm contracts, it creates negative pressure that increases the thoracic volume and pulls air into the lungs.
- The lungs and chest wall have the ability to expand during inspiration (compliance) and then to recoil or return to the resting state with expiration.

Inspiration



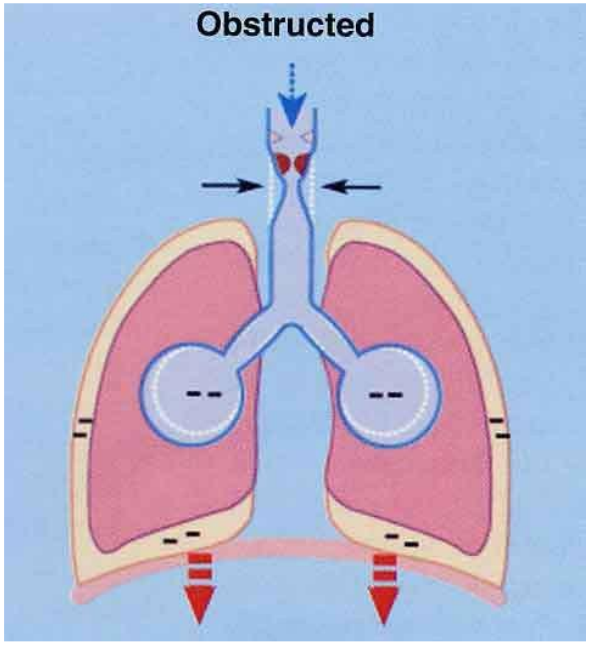
Expiration



Physiology: effect of obstruction

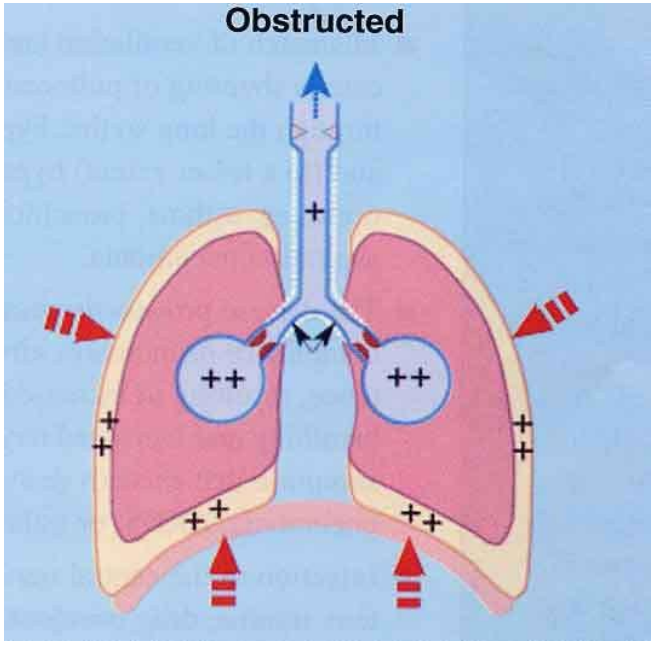
- The work of breathing is tied to the muscular effort required for ventilation, which can be increased in cases of airway obstruction or disorders that increase the stiffness of the lungs.

Extrathoracic Upper Airway Obstruction



epiglottitis, laryngotracheobronchitis, foreign body aspiration

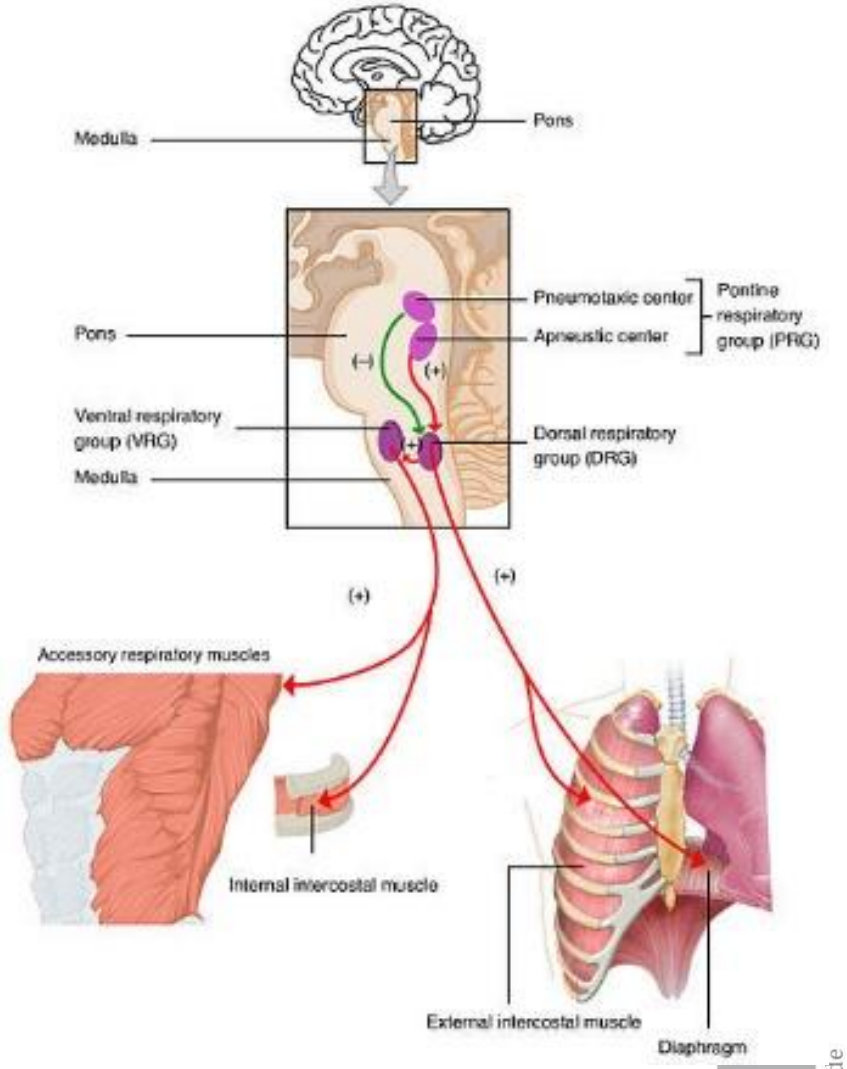
Intrathoracic Upper Airway Obstruction



asthma, bronchiolitis

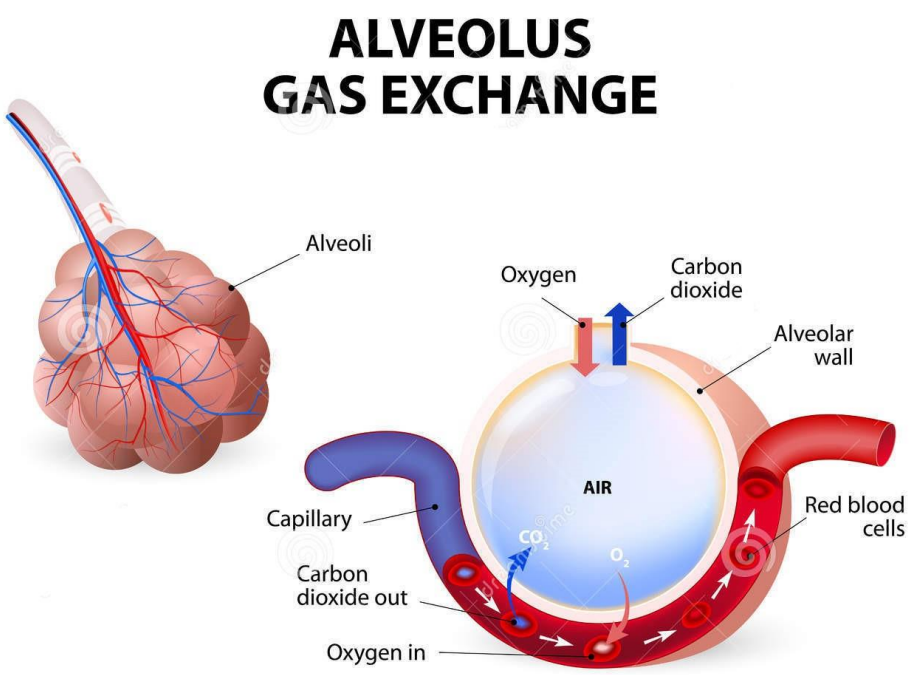
Respiratory physiology

- The respiratory center in the brain controls respiration, sending impulses to the respiratory muscles to contract and relax.
- Breathing is usually automatic as the nervous system adjusts the ventilatory rate and volume to maintain normal gas exchange (Brashers, 2014).
- Chemoreceptors monitor the pH, PaCO2, and PaO2 in the arterial blood and send signals to the respiratory center to increase ventilation in cases of arterial hypoxemia.



Respiratory physiology

- Effective gas exchange requires a near even distribution of ventilation and perfusion (oxygenated blood flow to all portions of the lungs).
- As oxygen diffuses across the alveolocapillary membrane, it dissolves in the plasma and the resulting increased partial pressure of oxygen (PaO2) helps bind the oxygen to the hemoglobin molecules for transport to the cells for metabolism.



- Carbon dioxide produced by cellular metabolism is dissolved in the plasma (PCO2) and/or as bicarbonate and travels back to the lungs where it diffuses across the alveolocapillary membrane.

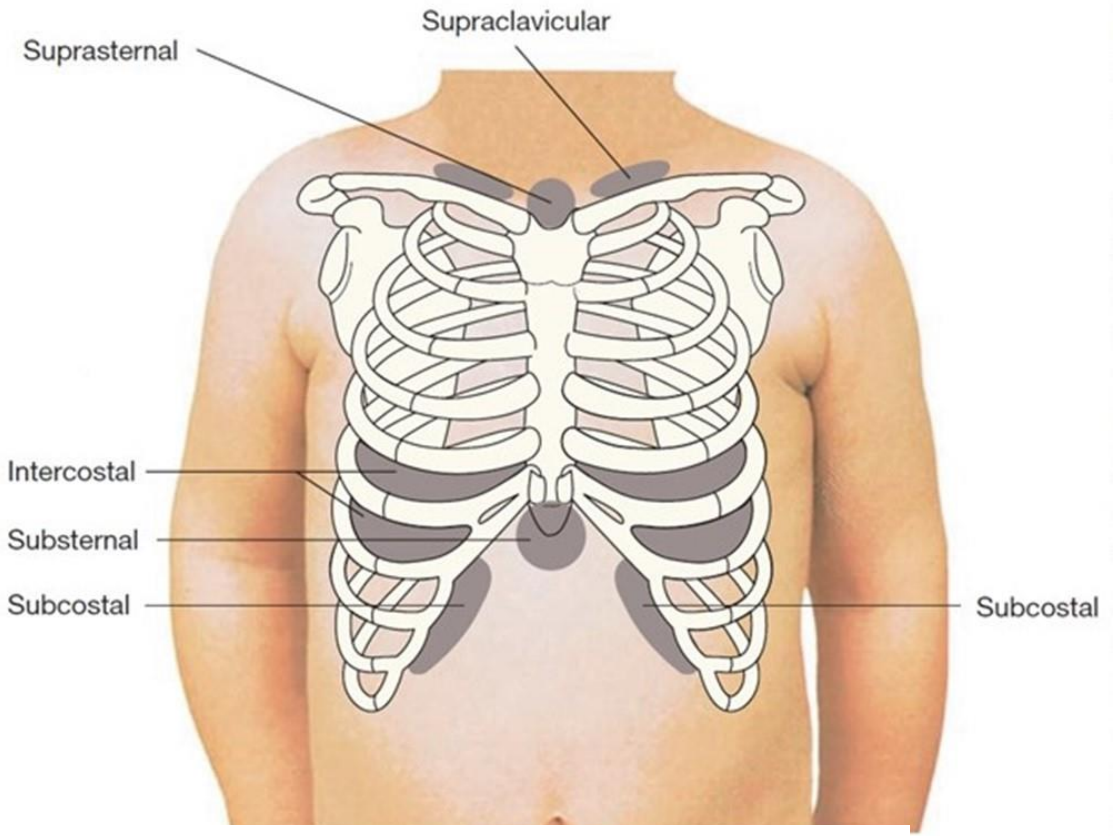
Peculiarities of the respiratory system in children

- Newborns are obligatory nose breathers. The only time newborns breathe through the mouth is when they are crying.
- The coordination of mouth breathing is controlled by maturing neurologic pathways, and infants up to 2 to 3 months of age do not automatically open the mouth to breathe when the nose is obstructed.

It is important to keep the newborn's nose patent for breathing and eating!

Peculiarities of the respiratory system in children

- The bronchi and bronchioles are lined with smooth muscle that develops after birth.
- Children under 6 years of age use the diaphragm to breathe because the intercostal muscles are immature.
- By 6 years of age the child uses the intercostal muscles more effectively.



The ribs are primarily cartilage and very flexible. In cases of respiratory distress, the negative pressure caused by the diaphragm movement causes the chest wall to be drawn inward, causing **retractions**.

Airway Evaluation in Children

Introduction

- Respiratory disease is one of the most common reasons that pediatric patients seek medical attention.

- Signs and symptoms can be subtle, and a careful history and physical examination are always useful in assessment of pediatric patients with respiratory complaints.

- Diseases of the chest can be divided into two major categories: **acquired** and **congenital**.

Introduction

- **Congenital** chest diseases are often **symptomatic at all times** rather than episodically.
  - a child who has chronic noisy breathing from a congenital vascular ring, for example, is not as likely as the patient with asthma to have intermittent periods of wheezing with long intervals of normal breathing.

- The spectrum of diseases involving the pediatric respiratory system is primarily dependent on the age of the patient; therefore, **age must be a primary consideration** in the differential diagnosis.

Medical History

- **Upper Respiratory Infection** predisposes to coughing, laryngospasm, bronchospasm, desat during anesthesia
- **Snoring or noisy breathing** (adenoidal hypertrophy, upper airway obstruction, OSA)
- **Chronic cough** (subglottic stenosis, previous tracheoesohageal fistula repair)
- **Productive cough** (bronchitis, pneumonia)
- **Sudden onset of new cough** (foreign body aspiration)
- **Inspiratory stridor** (macroglossia, laryngeal web, laryngomalacia, extrathoracic foreign body)
- **Hoarse voice** (laryngitis, vocal cord palsy, papillomatosis)

Medical History

- **Asthma and bronchodilator therapy** (bronchospasm)
- **Repeated pneumonias** (GERD, Cystic Fibrosis, bronchiectasis, tracheoesophageal fistula, immune suppression, congenital heart disease)
- History of **foreign body aspiration**
- **Previous anesthetic problems** (difficulty intubation/extubation or difficulty with mask ventilation)
- **Atopy, allergy** (increased airway reactivity)
- **History of congenital syndrome** (Pierre Robin Sequence, Treacher Collins, Klippel-Feil, Down's Syndrome, Choanal atresia)
- **Environmental**: smokers

History

- Each pediatric history should include the **perinatal history**:
  - ex. respiratory distress at birth or intubation

- **Prematurity** with prolonged need for supplemental oxygen may **suggest bronchopulmonary dysplasia** with associated structural lung abnormalities.

- **Noisy breathing starting early in life** suggests **congenital airway obstruction** and should be evaluated.

History

- Regardless of cause, **failure to thrive** is a worrisome finding, whereas excellent weight gain in a child with noisy breathing is reassuring.

- **Distinguishing between constant and intermittent symptoms** can be one of the most important means of diagnosing diseases of the pediatric chest.

- A good "**cough history**" and "**wheeze history**" are important and have similar elements.

History

- The clinician should inquire about the
  - chronicity of the symptoms
  - association with feeding
  - upper respiratory infections
  - exposures (pets, dust, and especially cigarette smoking are important), and
  - fevers

History

The nature of the cough is important:

- ***wet*** or ***dry***
- ***paroxysmal*** or ***continuous,*** and
- ***staccato*** (as seen in neonatal chlamydial pneumonia)
- **posttussive emesis** is a "red flag" to the clinician.
- a **persistent cough that disappears in sleep** strongly suggests the diagnosis of **habit** (psychogenic) **cough**.
- the **cough that awakens the child at night** or keeps the child up much of the night is another worrisome historical finding.

History

- In evaluating the infant with frequent episodes of cough and/or wheeze, the clinician should inquire about symptoms and signs of **gastroesophageal reflux** (GER):

Because reflux is worse when the patient is lying down, **symptoms** tend to be more **prominent at night and during naps**.

- food refusal
- arching
- pain behaviors
- frequent spitting

- milk or formula found on the bed next to the infant's head in the morning
- recurrent croup
- hoarseness
- laryngomalacia

History

- A **family history of atopy** including eczema and environmental allergies should be investigated.
- In inquiring about **cystic fibrosis**, an autosomal recessive trait, an **extended family medical history** including grandparents and cousins should be taken.
- **Frequent infections** in parents or siblings, particularly those requiring hospitalization, suggest **possible immunodeficiency** in the family.
- **Immunization history** is essential in identifying patients at risk for pertussis.

Physical examination

- The infant or toddler is best examined with his or her shirt off while being held upright in the arms of a parent.
- The patient should face the parent; this maximizes contact with the parent and allows the patient to feel safe.
- The room should be at a comfortable temperature.
- The stethoscope head should be warmed in the clinician's hand or pocket for several minutes before use.

Physical examination

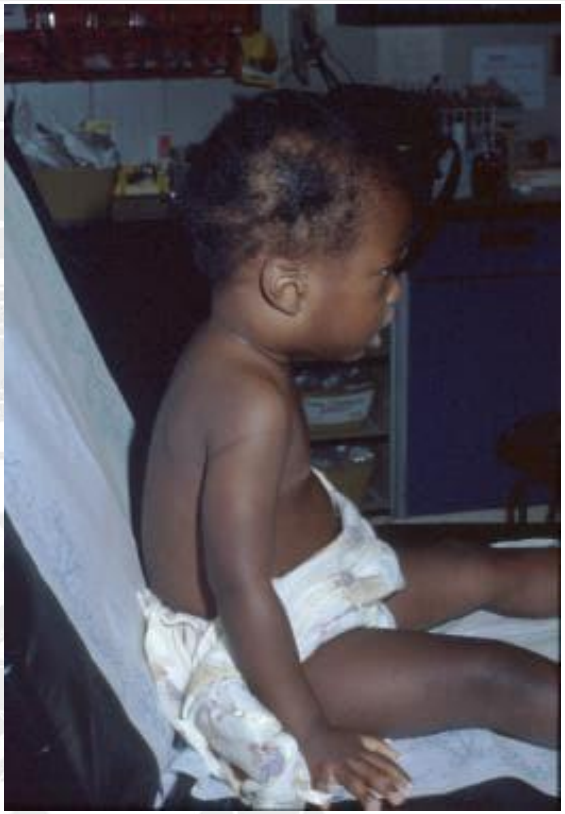
Table: Normal respiratory rate ranges in children

Age group	Age	Normal respiratory rate range
Infant	0–12 months	30–60/min
Toddler	1–3 years	24–40/min
Preschooler	4–5 years	22–34/min
School age	6–12 years	18–30/min
Adolescent and adult	13 years and older	12–16/min

Physical examination

Tripod position:

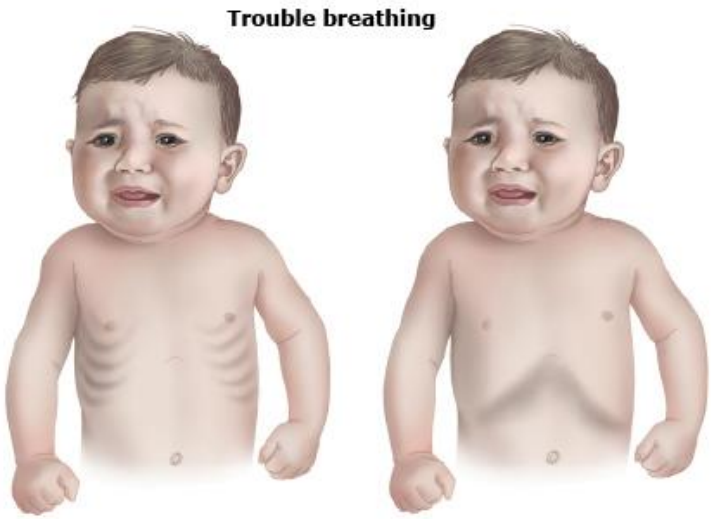
- Lean forward while sitting and rest the hands on the knees
- Seen in patients with asthma and respiratory distress in airways obstruction



Inspection

- **Decreased subcutaneous adipose tissue** as seen in a cystic fibrosis patient should be noted.
- The **pattern of breathing** should always be evaluated with the child disrobed.
- **Suprasternal** and **intercostal retractions** reflect excessive negative pleural pressure and can be seen in normal children with thin chest walls after vigorous exercise.
- In infants with **obstructive lung disease**, the **lower ribs** can be felt to **pull inwards on inspiration**. This is the palpable aspect of a subcostal retraction.

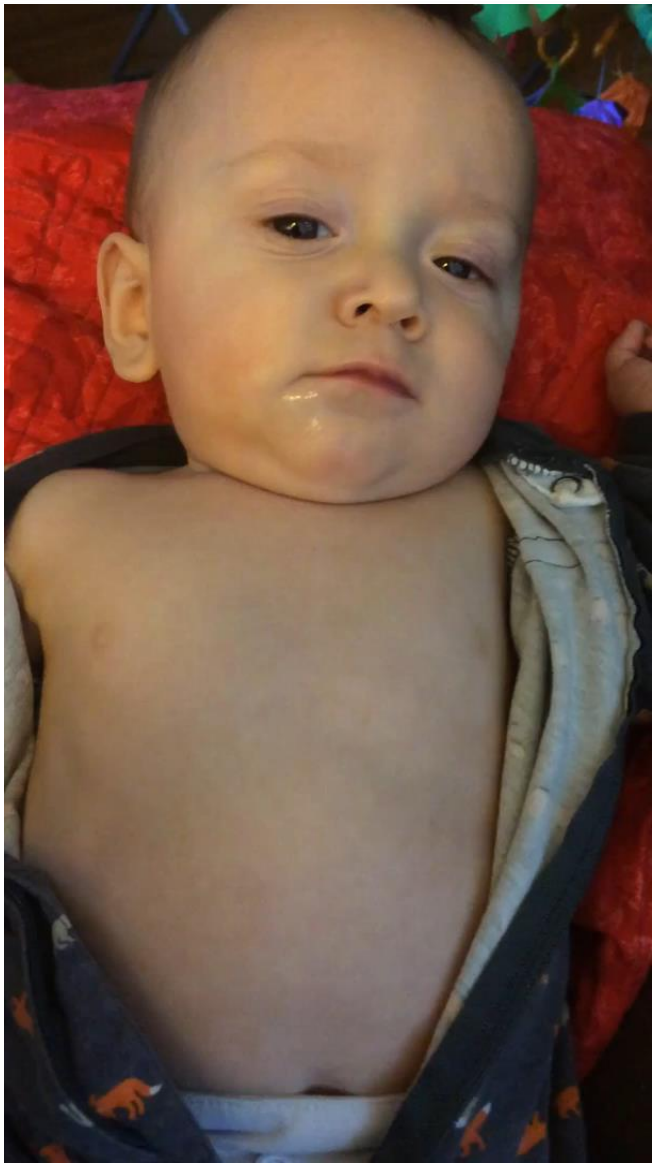
Any use of expiratory musculature is abnormal!



Inspection

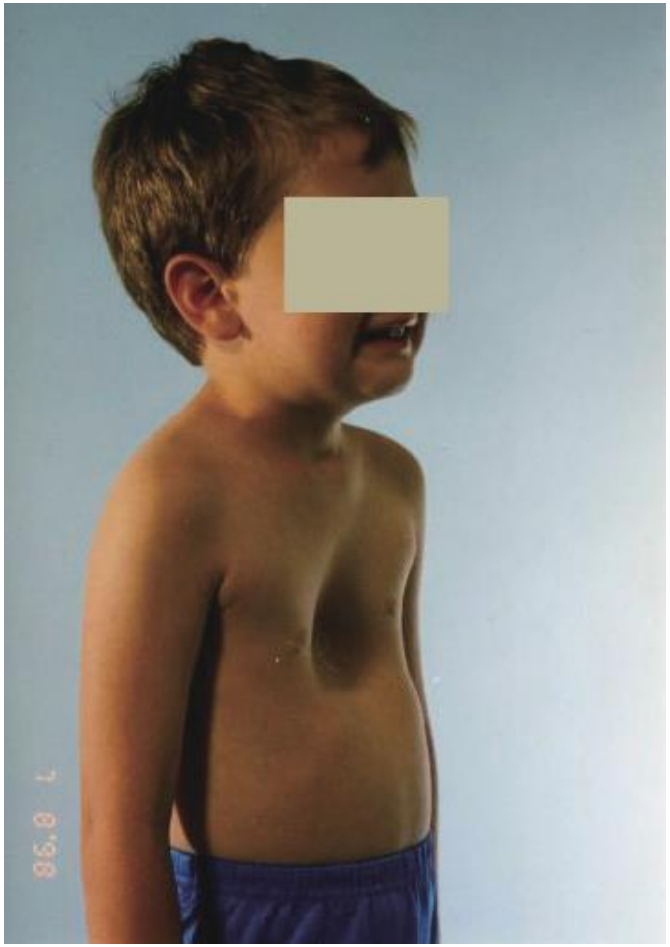
- **Subcostal retractions** are **always pathologic** and are the result of hyperinflated lungs and a flattened diaphragm pulling inward on the chest wall.

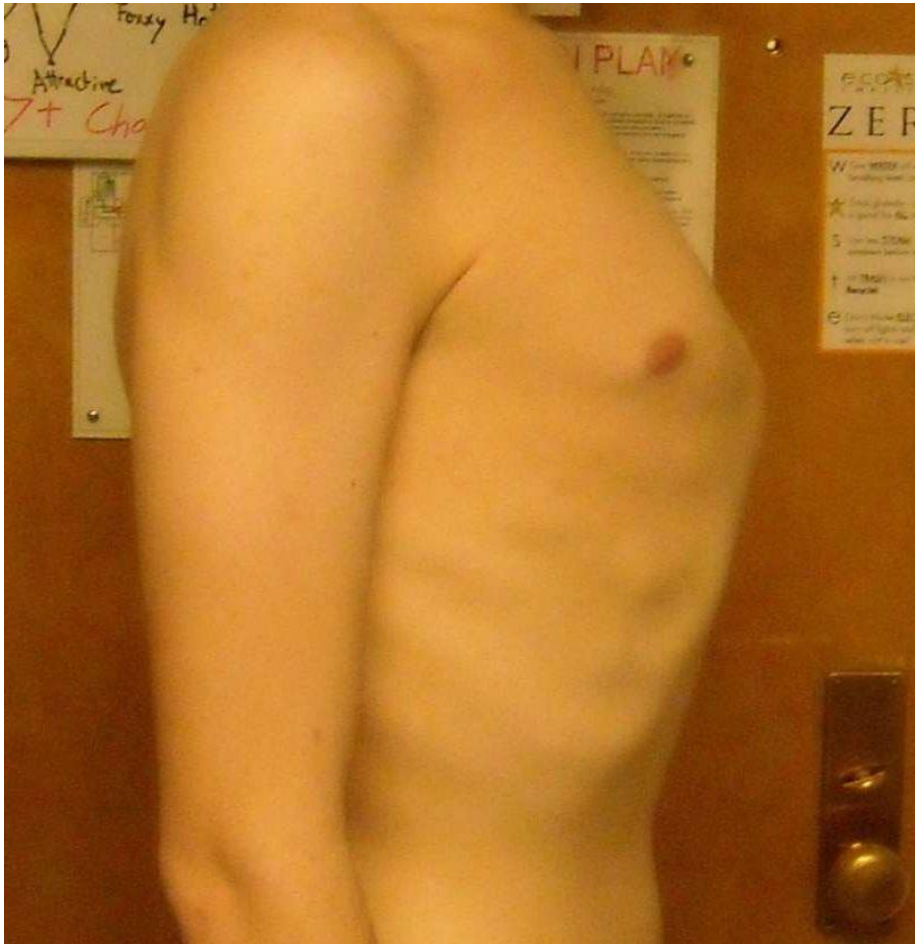
- In advanced lung disease, the use of accessory muscles of inspiration can be noted:
  - the sternocleidomastoid muscle, for example, helps lift the chest (in a “bucket handle” fashion) and increase its anteroposterior diameter, thereby increasing intrathoracic volume.



Inspection

- Chest wall deformities such as **pectus excavatum** or **pectus carinatum (pigeon chest)** should be noted.





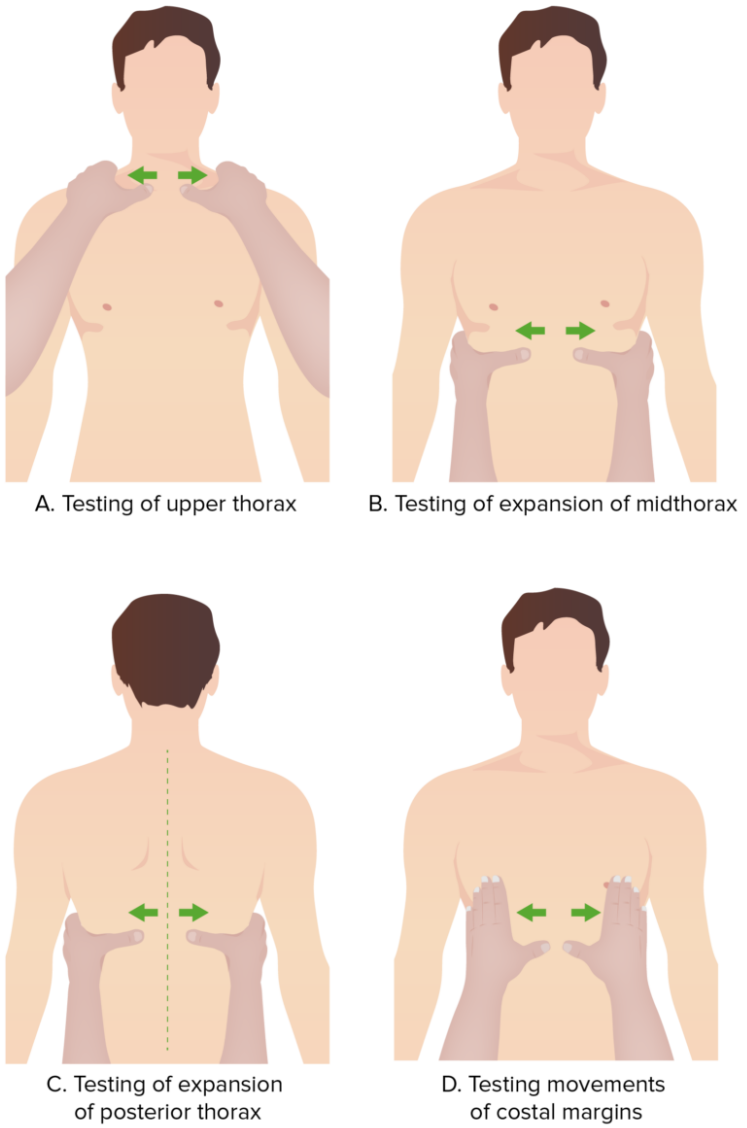
Palpation

Palpation of the chest can reveal significant findings:

- The examiner places the hands on either side of the chest as the patient takes a deep breath.

- The chest should expand symmetrically;

- **asymmetry** can be seen in unilateral pulmonary hypoplasia, mainstem bronchial obstruction, and diaphragmatic paresis.



Palpation

Palpation of the chest can reveal significant findings:

- Vocal fremitus should be assessed in patients with suspected pleural fluid accumulation
  - the vibrations transmitted from the larynx as the child says “99” are diminished when there is an accumulation of air or fluid in the pleural space.

- Infants and children with tracheomalacia and bronchomalacia often have a **palpable vibration in the back**.
  - palpable vibrations in only one hemithorax suggest a partial obstruction of the mainstem bronchus in that hemithorax as seen in bronchomalacia.

Percussion

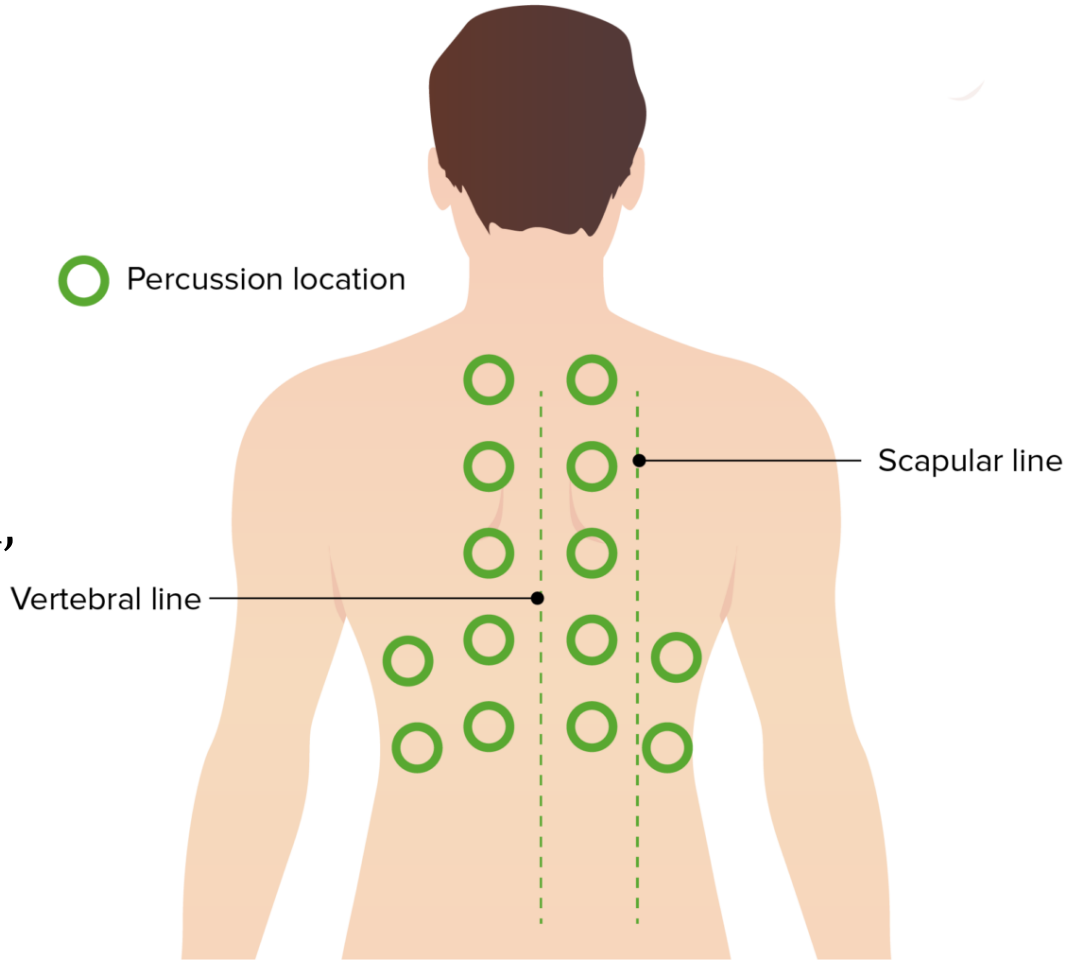
- Percussion of the chest can reveal much more than hyperresonance and dullness over an area of consolidation.

- **Air trapping** is the hallmark of small airway disease and results in a **depressed position of the diaphragm**:
  - ordinarily the diaphragm can be found just at or slightly below the tip of the scapula when the patient's arm is at his or her side in children 5 years old and younger.
  - In the patient with hyperinflation, the diaphragm is found several fingerbreadths below the scapular tips. This finding, even in the absence of wheezing on auscultation, suggests a lesion of the small airways.

Percussion

- An **area of consolidation** or **pleural effusion** results in **dullness to percussion**.

- Another disorder causing **asymmetry of percussion** of the two hemithoraces is **diaphragmatic eventration**, which is a congenital lesion of the diaphragm in which the diaphragm is replaced with a thin fibrous membrane without contractile properties.



Auscultation

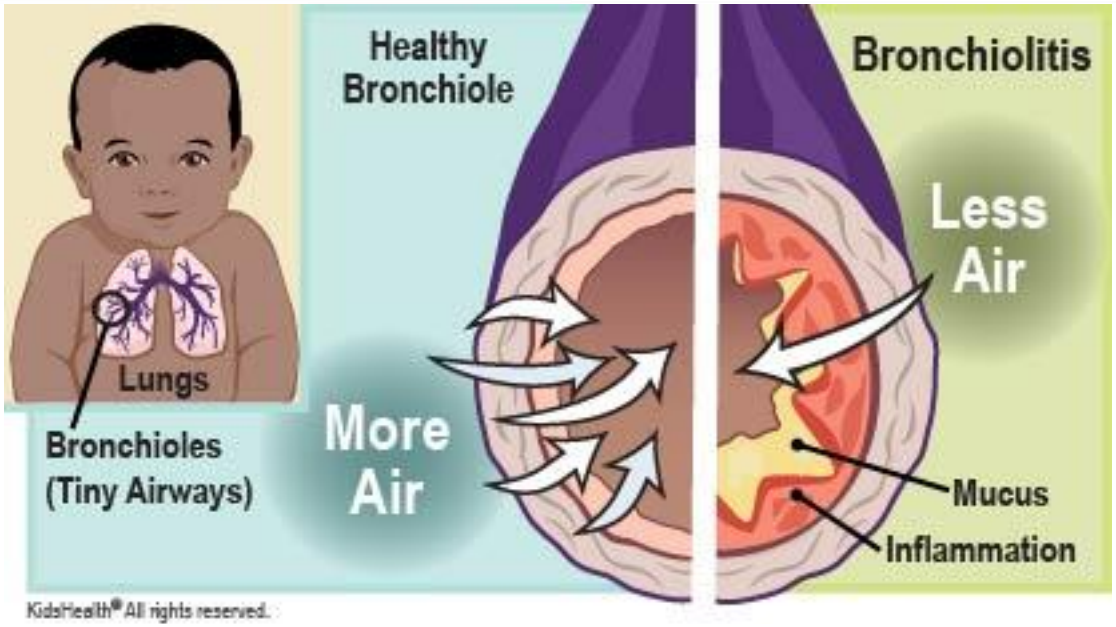
Abnormal ("adventitial") breath sounds include **crackles** and **wheezes**.

- **Wheezes** are *continuous* sounds, whereas crackles (formerly referred to as *rales*) are *discontinuous*.
- Wheezes and crackles can be inspiratory or expiratory, although crackles are more commonly heard on inspiration and wheezes are more commonly heard on expiration.
- Wheezes probably arise from the vibration within the walls of narrowed large and medium-sized airways.
- In a patient experiencing an acute exacerbation of asthma, the lungs have wheezes in a range of pitches (described as *polyphonic*) with substantial regional differences in auscultation.
- Patients with central airway obstruction such as tracheomalacia, on the other hand, have a single pitch of wheeze that sounds the same in all lung fields *(monophonic)* and is heard loudest over the central airway that is obstructed.

Bronchiolitis

Basics

- Respiratory infection of the bronchioles
- Occurs in early childhood (younger than 1 yr)
- Caused by viral infection



Assessment/History

- Length of illness or fever
- Has infant been seen by a doctor
- Taking any medications
- Any previous asthma attacks or other allergy problems
- How much fluid has the child been drinking

Bronchiolitis

Signs & symptoms

- Acute respiratory distress
- Tachypnea
- May have intercostal and suprasternal retractions
- Cyanosis
- Fever & dry cough
- May have wheezes - inspiratory & expiratory
- Confused & anxious mental status
- Possible dehydration

Management

- Assess & maintain airway
- When appropriate let child pick POC
- Clear nasal passages if necessary
- Prepare to assist with ventilations
- IV LR or NS TKO rate
- Intubate if airway management becomes difficult or fails

Causes of Chronic or Recurrent Wheezing

- Asthma
  - Exercise-induced asthma
- GER
- Hypersensitivity reactions (e.g., ABPA)
- Cystic fibrosis
- Aspiration
  - Tracheoesophageal fistula
  - Foreign body
  - GER
  - Laryngeal cleft
  - Pharyngeal dysmotility
- Extrinsic masses
  - Vascular ring
  - Cystic adenomatoid malformation
  - Lymph nodes
  - Tumors
- Ciliary dyskinesia syndromes
- Tracheomalacia and/or bronchomalacia
- Congestive heart failure
- Bronchopulmonary hemosiderosis or Heiner syndrome
- Endobronchial lesions including localized stenosis
- Interstitial pneumonitides
- Bronchiolitis obliterans

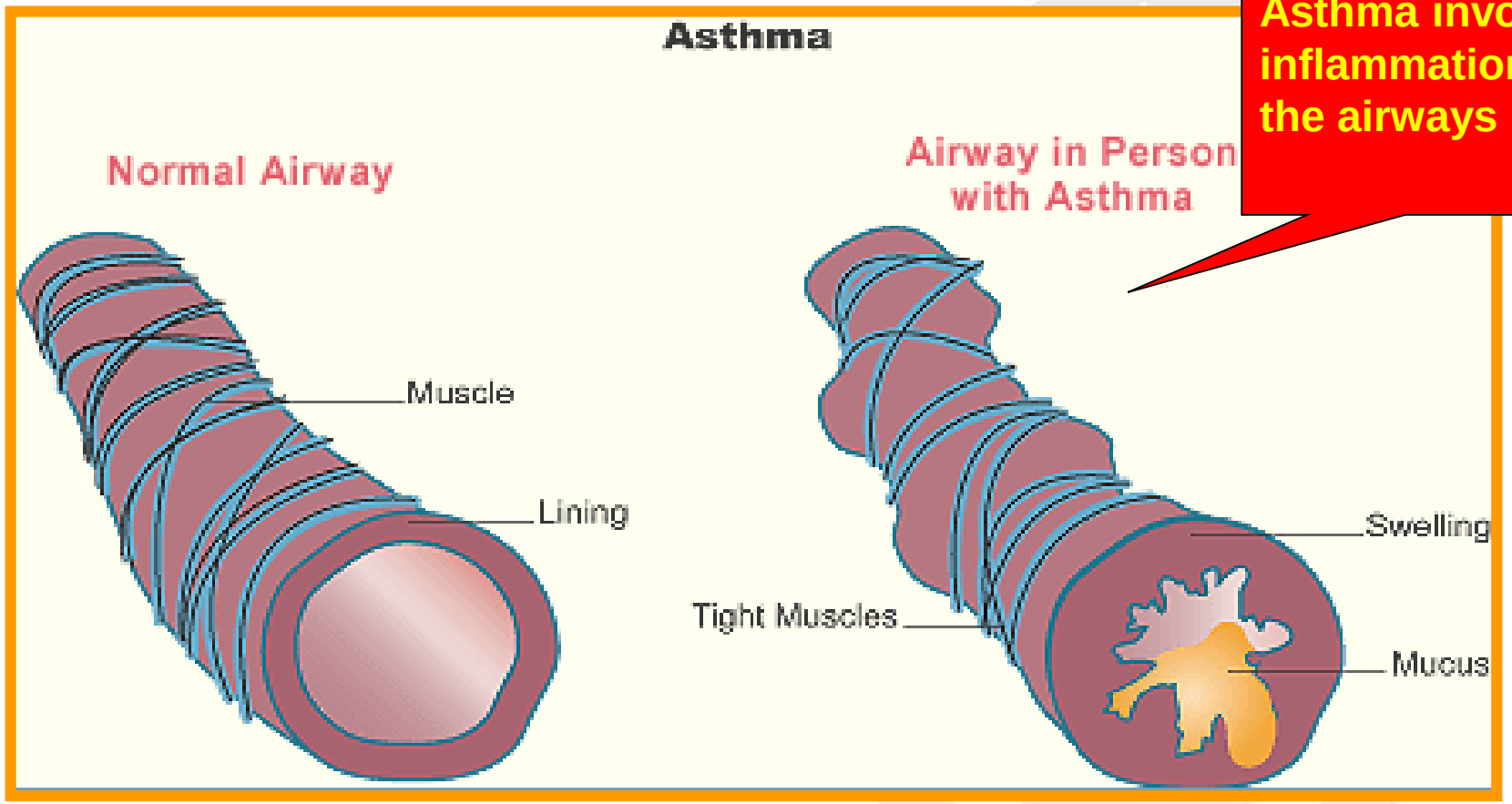
ABPA, Allergic bronchopulmonary aspergillosis; *GER,* gastroesophageal reflux.

Asthma

- Chronic disease of the airways that may cause
  - Wheezing
  - Breathlessness
  - Chest tightness
  - Nighttime or early morning coughing

- Episodes are usually associated with widespread, but variable, airflow obstruction within the lung that is often reversible either spontaneously or with treatment.

Pathology of Asthma



Asthma involves inflammation of the airways

Indoor Air Exposures & Asthma Development

Biological Agents

- Sufficient evidence of causal relationship
  - Cat
  - Cockroach
  - House dust mite
- Sufficient evidence of an association
  - Dog
  - Fungus/Molds
  - Rhinovirus
- Limited or suggestive evidence of association
  - Domestic birds
  - Chlamydia and Mycoplasma pneumonia
  - RSV

Chemical Agents

- Sufficient evidence of causal relationship
  - Environmental tobacco smoke (among pre-school aged children)
- Sufficient evidence of association
  - NO_2, NO_X (high levels)
- Limited or suggestive evidence of association
  - Environmental Tobacco Smoke (among school-aged, older children, and adults)
  - Formaldehyde
  - Fragrances

Diagnosing Asthma: Medical History

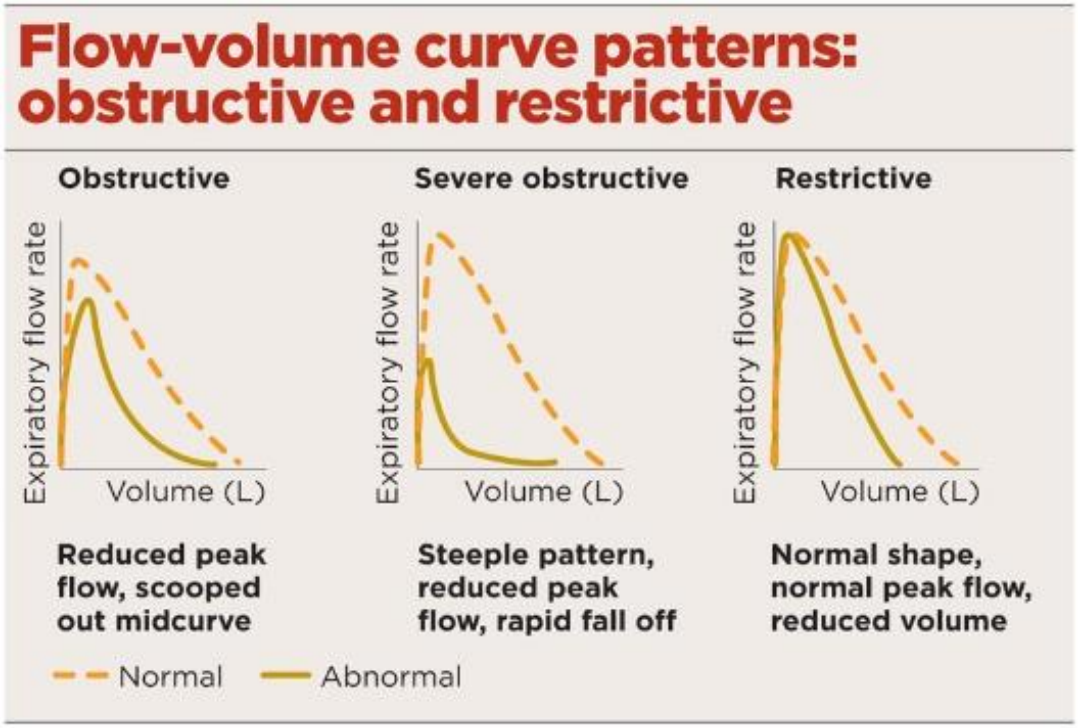
- Symptoms
  - Coughing
  - Wheezing
  - Shortness of breath
  - Chest tightness
- Symptom Patterns
- Severity
- Family History

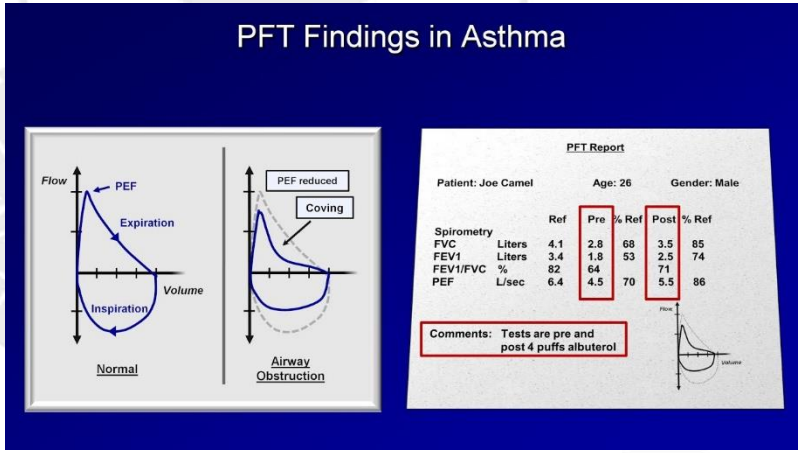
Diagnosing Asthma

- Troublesome cough, particularly at night
- Awakened by coughing
- Coughing or wheezing after physical activity
- Breathing problems during particular seasons
- Coughing, wheezing, or chest tightness after allergen exposure
- Colds that last more than 10 days
- Relief when medication is used
- Wheezing sounds during normal breathing
- Hyperexpansion of the thorax
- Increased nasal secretions or nasal polyps
- Atopic dermatitis, eczema, or other allergic skin conditions

Diagnosing Asthma: Spirometry

Test lung function when diagnosing asthma



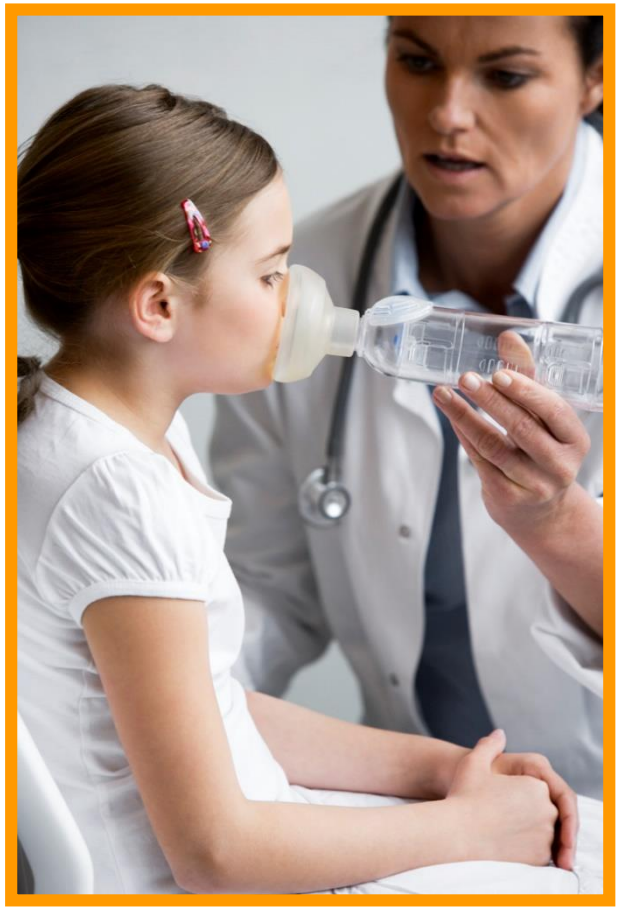


Medications to Treat Asthma

- Medications come in several forms.
- Two major categories of medications are:
  - Long-term control
    - Taken daily over a long period of time
    - Used to reduce inflammation, relax airway muscles, and improve symptoms and lung function
      - Inhaled corticosteroids
      - Long-acting beta$_2$-agonists
      - Leukotriene modifiers
  - Quick relief
    - Used in acute episodes
    - Generally short-acting beta$_2$agonists

Medications to Treat Asthma: How to Use a Spray Inhaler

The health-care provider should evaluate inhaler technique at each visit.



Remember to breathe in slowly.

1. Take off the cap.
   Shake the inhaler.

2. Stand up.
   Breathe out.

3. Put the inhaler in your mouth or put it just in front of your mouth. As you start to breathe in, push down on the top of the inhaler and keep breathing in slowly.

4. Hold your breath for 10 seconds.
   Breathe out.

Auscultation

- **Crackles** are believed to arise from the popping of fluid menisci within airways.
- Coarse crackles are often audible at the mouth and are a late finding in cystic fibrosis patients with advanced bronchiectasis.

- **Rhonchi** refers to the sound made by pooled secretions in the central airways, which can be categorized as harsh, low-pitched central wheezes or coarse, central crackles (depending on the nature of the sounds heard)

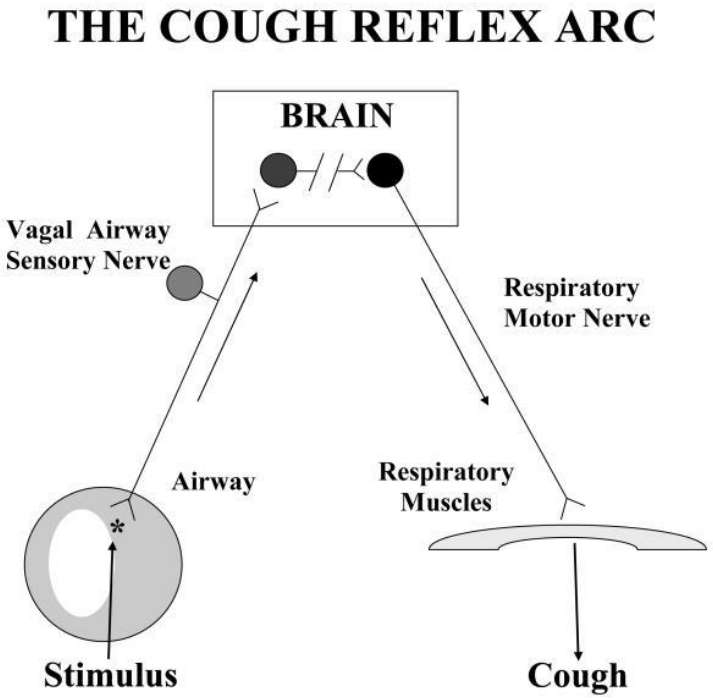
Friction rubs are creaking sounds heard during both phases of respiration as inflamed pleural surfaces rub over one another.

One of the most important abnormal findings in children is the **absence of breath sounds** over an area of **collapse** or **consolidation**.

Signs and symptoms of respiratory diseases in children

Cough

- Persistent or recurrent cough represents one of the most common and vexing problems in pediatrics.
- In most circumstances, the tracheobronchial tree is kept clean by airway macrophages and the mucociliary escalator.



- Cough becomes an important component of airway clearance when excessive or abnormal materials are present, or when mucociliary clearance is reduced, such as during a viral respiratory illness.

Causes of Cough According to Age

Infancy (Younger Than 1 Year Old)

Congenital and Neonatal Infections

Chlamydia
Viral (e.g., RSV, CMV, rubella)
Bacterial (e.g., pertussis)
Pneumocystis jiroveci

Congenital Malformations

Tracheoesophageal fistula
Vascular ring
Airway malformations (e.g., laryngeal cleft)
Pulmonary sequestration

Other

Cystic fibrosis
Asthma
Aspiration
Recurrent viral bronchiolitis/bronchitis
GER
Interstitial pneumonitides
Lymphoid interstitial pneumonitis
Diffuse interstitial pneumonitis

Preschool

Inhaled foreign body
Asthma
Suppurative lung disease
    Cystic fibrosis
    Bronchiectasis
Right middle lobe syndrome
Ciliary dyskinesia syndromes
Upper respiratory tract disease
Recurrent viral infection/bronchitis
Passive smoke inhalation
GER
Interstitial pneumonitides
Pulmonary hemosiderosis

Causes of Cough According to Age

School Age to Adolescence

Asthma
Cystic fibrosis
Mycoplasma pneumoniae infection
Psychogenic or habit cough
Cigarette smoking
Pulmonary hemosiderosis
Interstitial pneumonitides
Ciliary dyskinesia syndromes

All Ages

Recurrent viral illness
Asthma
Cystic fibrosis
Granulomatous lung disease
Foreign body aspiration
Pertussis infection

Characteristics of Chronic Cough and Associated Conditions

Characteristic	Associated Condition
Loose, productive	Cystic fibrosis, bronchiectasis, ciliary dyskinesia
Croupy	Laryngotracheobronchitis
Paroxysmal	Cystic fibrosis, pertussis syndrome, foreign body inhalation, *Mycoplasma, Chlamydia*
Brassy	Tracheitis, upper airway drainage, psychogenic cough
After feedings	Pharyngeal incoordination, pharyngeal mass, tracheoesophageal fistula, GER
Nocturnal	Upper respiratory tract disease, sinusitis, asthma, cystic fibrosis, GER
Most severe in morning	Cystic fibrosis, bronchiectasis
With exercise	Asthma (including exercise induced), cystic fibrosis, bronchiectasis
Loud, honking, or bizarre	Psychogenic cough
Disappears with sleep	Psychogenic cough

GER, Gastroesophageal reflux.

Diagnostic Approach to Cough

- Complete history and physical examination
- Chest and sinus radiographs
- CBC with differential
- Pulmonary function tests (including bronchoprovocation tests)
- Sweat test (pilocarpine iontophoresis method)
- Trial of bronchodilators
- Sputum for Gram stain, AFB (Acid-fast bacillus), bacterial, viral, and fungal cultures
- Quantitative immunoglobulins
- Tuberculin skin test/anergy panel
- Serologic tests or PCR for *Mycoplasma pneumoniae*
- Bronchoscopy with bronchoalveolar lavage
- Barium swallow

Stridor

- Stridor is characteristically a harsh inspiratory noise created by obstruction of the larynx or the extrathoracic trachea.
- With a mild degree of airway narrowing, breath sounds may be normal when the infant or child is at rest, but with any activity that increases tidal breathing (e.g., crying, feeding, agitation), inspiratory stridor may become noticeable.

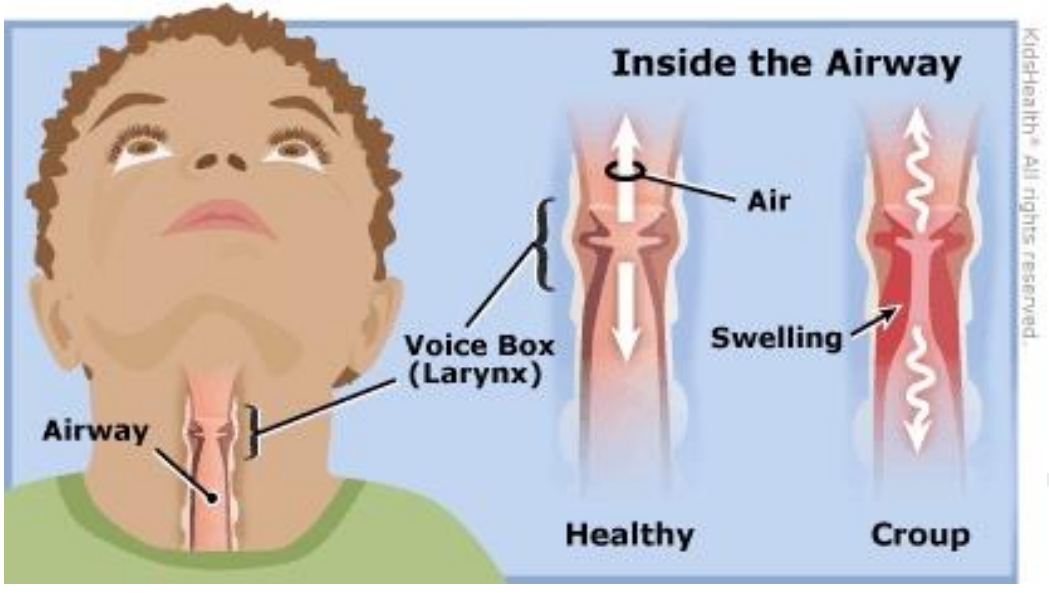
Causes of Recurrent or Chronic Stridor

Croup	Foreign body in esophagus
Infectious	Thyromegaly
Allergic/angioneurotic edema, GER	Pharyngeal or laryngeal masses
Laryngomalacia	Papilloma
Tracheomalacia	Hemangioma
Subglottic stenosis	Laryngocele
Extrinsic airway compression	Web
Vascular ring	Foreign body
Mediastinal mass	Tracheoesophageal fistula
Lobar emphysema	Vocal cord paralysis
Bronchogenic cyst	Psychogenic

GER, Gastroesophageal reflux.

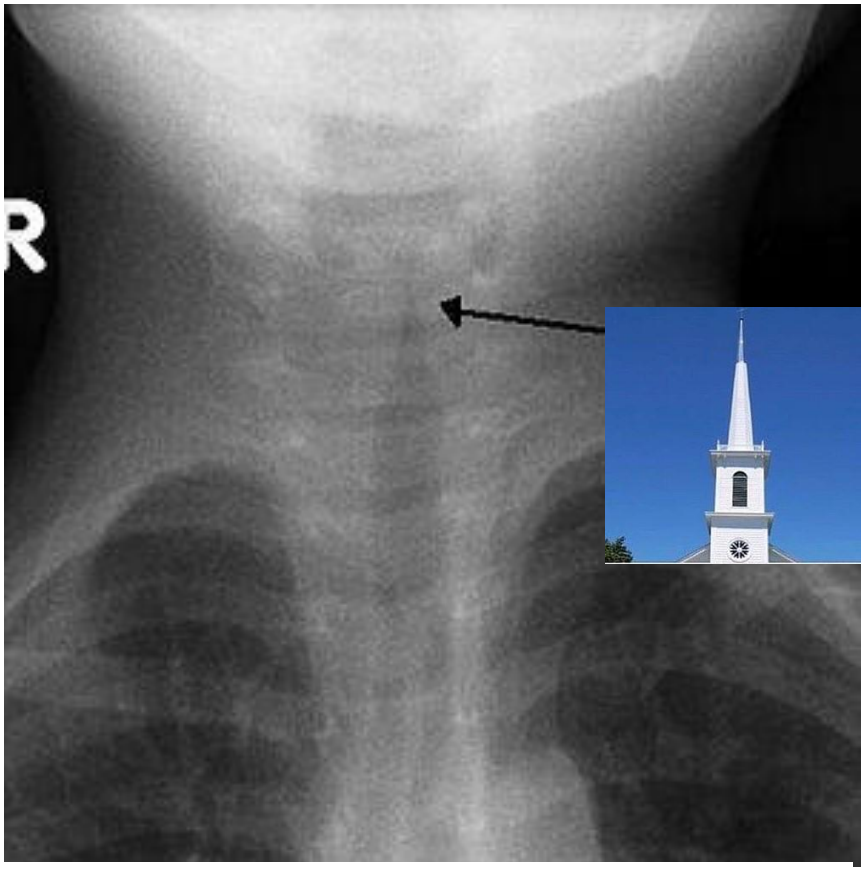
Stridor

- The most common cause of inspiratory stridor in the pediatric population is **infectious croup** (acute laryngotracheobronchitis).
- This disease is most commonly caused by a respiratory virus (parainfluenza, respiratory syncytial, influenza, or rhinovirus), and the patient typically has coryza for 24 to 48 hours before the appearance of croupy cough, hoarseness, and stridor.



Stridor

- Occasionally the inflammatory process may spread to the smaller airways and produce wheezing in addition to these symptoms.
- The “steeple sign” is a characteristic radiographic sign on anteroposterior projections that may be accompanied by marked dilation of supraglottic structures, particularly on lateral films.
- In the majority of patients, serious airway obstruction does not occur and the disease is self-limited.

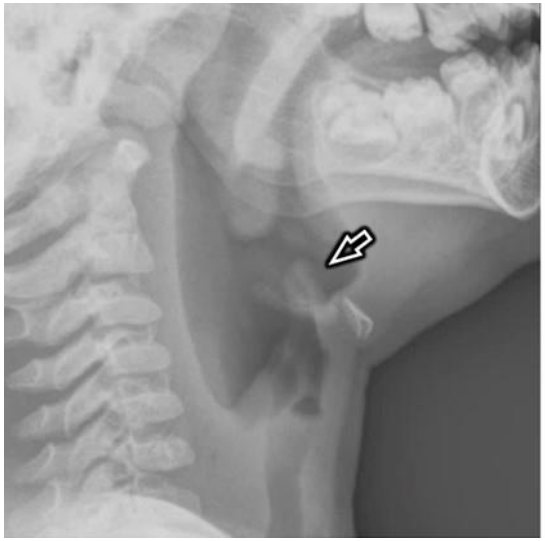


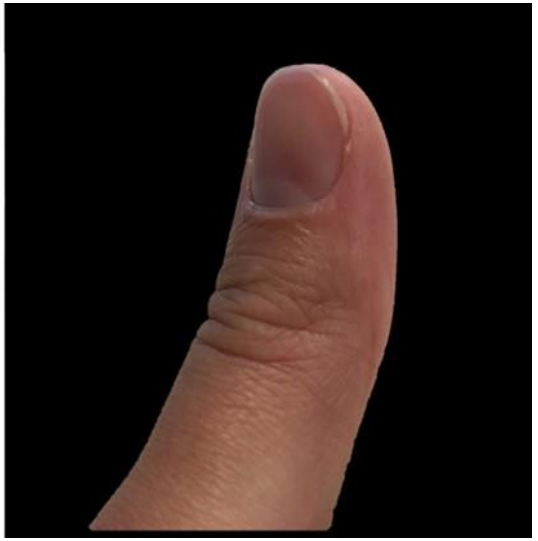
- Medically managed with oxygen and mist therapy, racemic epinephrine neb and IV dexamethasone (0.25-0.5mg/kg)
- Indications for intubation: progressive intercostal retraction, obvious respiratory fatigue, and central cyanosis

Stridor

Epiglottitis

- Etiology: Haemophilus influenzae type B; occurs in children ages 2-6 years
- Progresses rapidly from a sore throat to dysphagia and complete airway obstruction (within hours)
- Signs of obstruction: stridor, drooling, hoarseness, tachypnea, chest retraction, preference for upright position
- Lateral X-ray of the neck: "thumb sign" (a)





- OR intubation/ENT present for emergency surgical airway
- Do NOT perform laryngoscopy before induction of anesthesia to avoid laryngospasm
- Inhalational induction in sitting position to maintain spontaneous respiratory drive

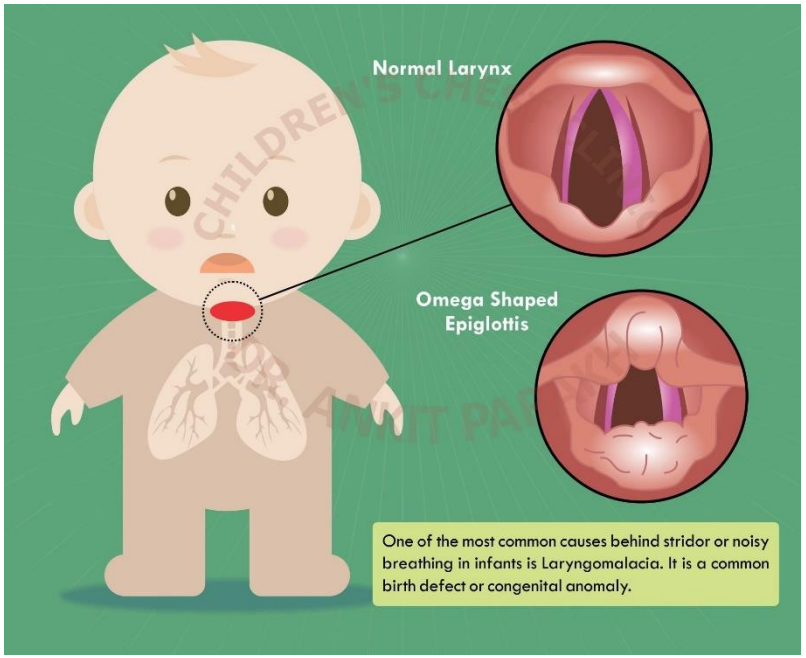
Stridor

- **Acute angioneurotic edema** is a less common cause of stridor. In most cases, it results from an allergic reaction and is potentially fatal.

- **Gastro Esophageal Reflux**: some children with anatomically normal airways suffer recurrent bouts of stridor, usually in the middle of the night, in the absence of signs of viral infection.
  - Treatment for GER is often helpful in these patients, suggesting that for many, occult GER explains these bouts of recurrent airway obstruction.

Stridor

- The stridor associated with **congenital laryngomalacia** generally begins within the first week of life, varies with activity, and is more noticeable in the supine position.



- Clinical symptoms may suggest the diagnosis; but if severe, bronchoscopic visualization of airway dynamics by flexible bronchoscopy is a safe and reliable method of excluding other causes of stridor.

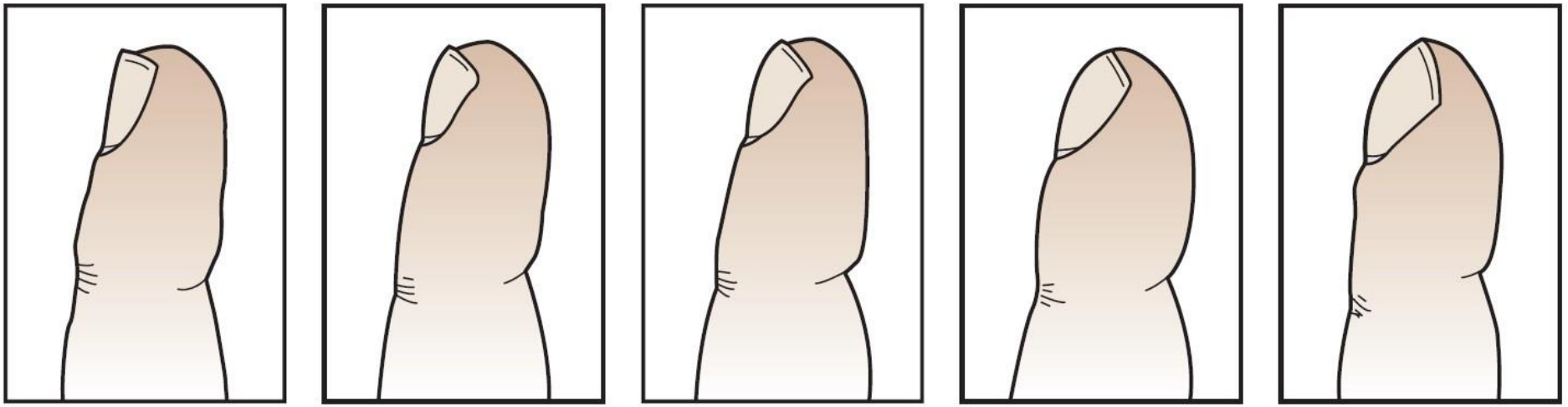
- Parents can be reassured that this entity is self-limited, becomes less marked after 6 to 10 months of age, and rarely causes serious problems.

Clinical Manifestations of Respiratory Failure and Imminent Respiratory Arrest

PHYSIOLOGIC CAUSE	CLINICAL MANIFESTATIONS
INITIAL SIGNS OF RESPIRATORY FAILURE	
The child is trying to compensate for oxygen deficit and airway blockage. Oxygen supply is inadequate; behavior and vital signs reflect compensation and beginning hypoxia.	Restlessness Tachypnea Tachycardia Diaphoresis
EARLY DECOMPENSATION	
The child tries to use accessory muscles to assist oxygen intake; hypoxia persists and efforts now waste more oxygen than is obtained.	Nasal flaring Retractions Grunting Wheezing Anxiety, irritability Mood changes Headache Hypertension Confusion
SEVERE HYPOXIA AND IMMINENT RESPIRATORY ARREST	
The oxygen deficit is overwhelming and beyond spontaneous recovery. Cerebral oxygenation is dramatically affected; central nervous system changes are ominous.	Dyspnea Bradycardia Cyanosis Stupor and coma

Digital clubbing

- Digital clubbing may point to the presence of lung disease. There are various stages of clubbing, from mild to severe:



Digital clubbing. The 0- to 4-point scale describes the spectrum of digital clubbing as follows:
1+, very mild; 2+, mild; 3+, moderate; and 4+, severe.

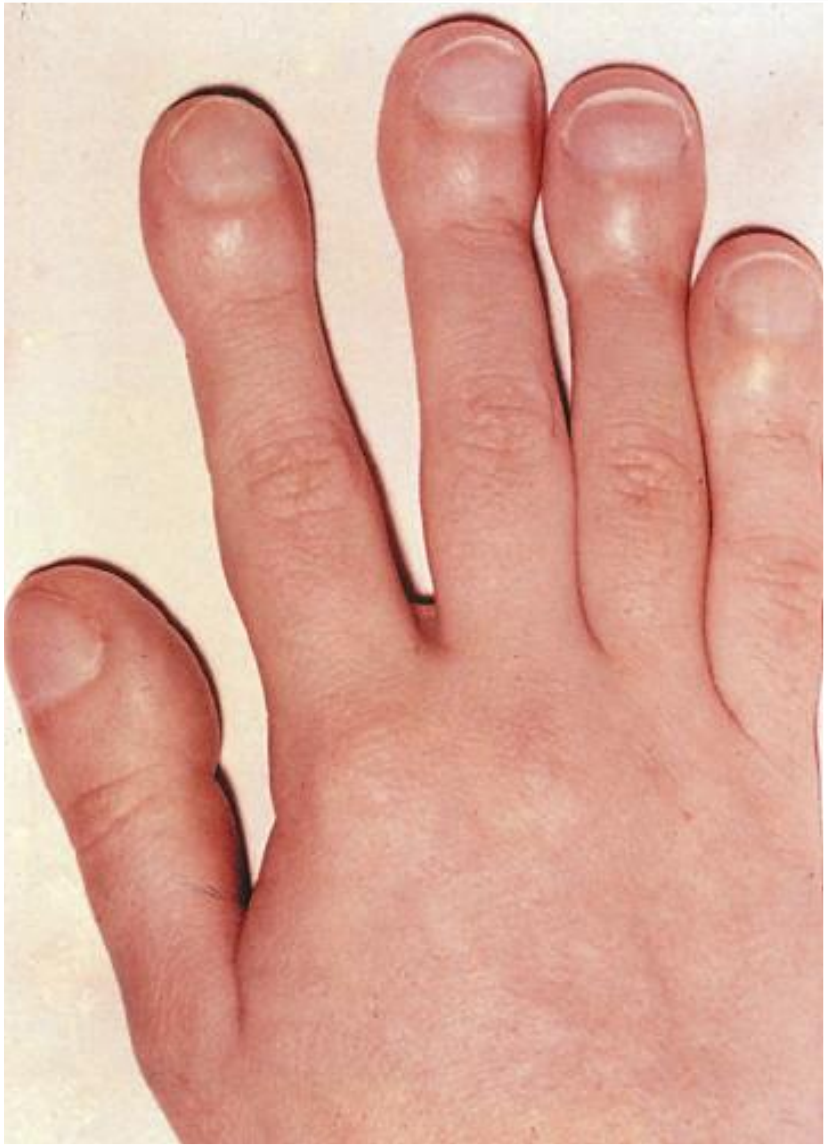
Digital clubbing

Causes of Clubbing

- Pulmonary
  - Cystic fibrosis
  - Other bronchiectasis
  - Pulmonary abscess
  - Empyema
  - Neoplasms
  - Interstitial fibrosis
  - Pulmonary alveolar proteinosis
  - Interstitial pneumonitis
  - Chronic pneumonia
- Cardiac
  - Cyanotic congenital heart disease
  - Subacute bacterial endocarditis
- Gastrointestinal or hepatic
  - Ulcerative colitis
  - Crohn disease
  - Polyposis
  - Biliary cirrhosis/atresia
- Familial
- Thyrotoxicosis

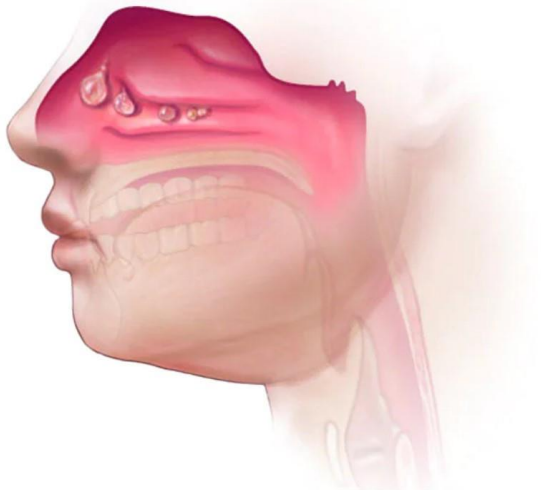
Digital clubbing

- Bronchiectasis from **cystic fibrosis** or from other chronic infectious causes is the major cause of clubbing among all pulmonary diseases.



The reminding of the physical examination

- **Nasal polyps** can be associated with cystic fibrosis, triad asthma, or significant atopy.



- An **increased second heart sound** on auscultation could suggest pulmonary hypertension.

ASSESSMENT GUIDE | The Child in Respiratory Distress*

Assessment Focus	Assessment Guideline
Position of comfort	• Is the child comfortable lying down? • Does the child prefer to sit up or in the **tripod position** (sitting forward with arms on knees for support and extending the neck)?
Vital signs	• Assess the rate and depth of respirations. See Table 5–9 for age-related respiratory rates. Is **tachypnea** (abnormally rapid respiratory rate) present? • Assess the pulse for rate and rhythm. See Table 5–11 for age-related heart rates.
Lung auscultation	• Are breath sounds bilateral, diminished, or absent? • Are **adventitious sounds** (wheezes, crackles, or rhonchi) present?
Respiratory effort (work of breathing)	• Is **stridor** (audible crow-like inspiratory and expiratory breath sounds) or wheezing present? Is grunting heard on expiration? • Is breathing easy or labored? • Are retractions present or are accessory muscles used to breathe? • Is nasal flaring present? • Can the child say a full sentence or is a breath needed every few words? Is the cry strong or weak? • Do the chest and abdomen rise simultaneously with inspiration or is **paradoxical breathing** present in which the chest and abdomen do not rise simultaneously?
Color	• What is the color of the mucous membranes, nail beds, or skin (pink, pale, cyanotic, or mottled)? • Does crying improve or worsen the color?
Cough	• Is the cough dry (nonproductive), wet (productive, mucousy), brassy (noisy, musical), or croupy (barking, seal-like)? • Is the coughing effort forceful or weak?
Behavior change	• Is irritability, restlessness, or change in level of responsiveness present?

Diagnostic and Laboratory Procedures/Tests for the Respiratory System

Diagnostic Testing

- Laboratory and radiographic evaluation extremely helpful with pathologic airway
- AP and lateral films and fluoroscopy may show site and cause of upper airway obstruction
- MRI/CT more reliable for evaluating neck masses, congenital anomalies of the lower airway and vascular system

Perform radiograph exam only when there is no immediate threat to the child's safety and in the presence of skilled personnel with appropriate equipment to manage the airway

Diagnostic Testing

- Intubation must not be postponed to obtain radiographic diagnosis when the patient is severely compromised.

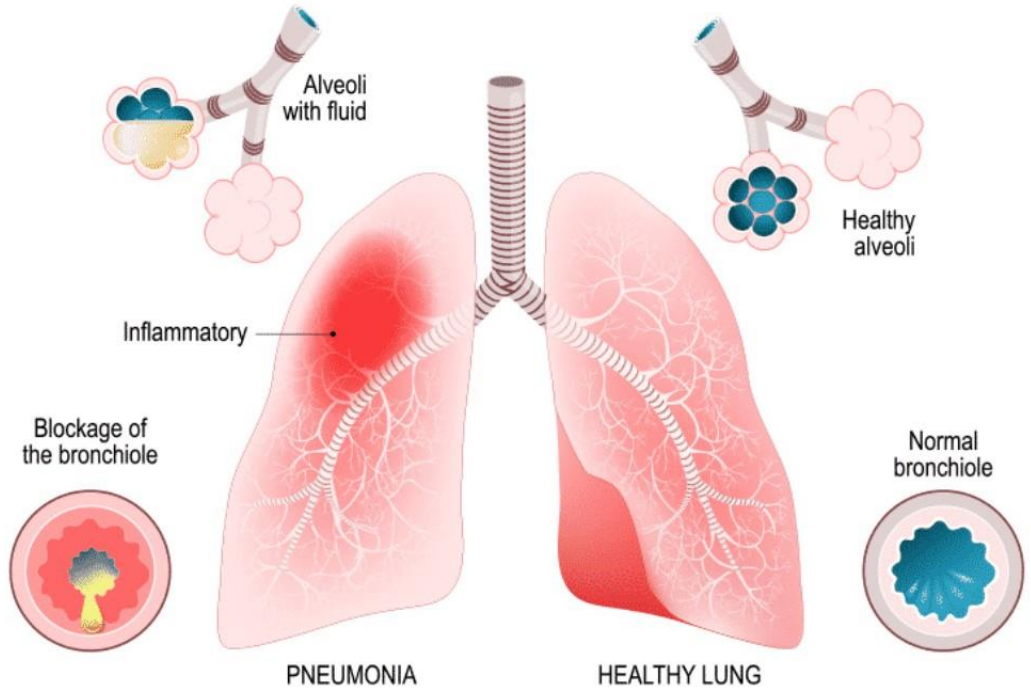
- Blood gases are helpful in assessing the degree of physiologic compromise; however, performing an arterial puncture on a stressed child may aggravate the underlying airway obstruction.

Paediatric Community Acquired Pneumonia

PNEUMONIA

"Inflammation of the lung"

-From Greek pneumōn meaning 'lung'



Community Acquired Pneumonia

- defined as the presence of signs and symptoms of pneumonia in a previously healthy child due to an infection which has been acquired outside hospital
- 120 million annual worldwide incidence of pneumonia in children <5 years old
- mortality rate 8.7% severe pneumonia
- >80% of all childhood pneumonia deaths occur in children <2 years old
- mortality rate reduced from 4-6 million in early 1980s to ~0.9 million in 2015[1]
- still second most common cause of childhood mortality worldwide second only to neonatal/preterm birth complications[1]

Community Acquired Pneumonia

- Incidence higher in boys[1]
- Incidence of severe pneumonia higher in children < 5 years of age[1]
- Marked seasonal pattern with winter preponderance for hospital admission due to pneumococcal infection (December and January 3-5x higher than August) [2]
- Winter preponderance also noted for many viral infections including respiratory syncytial virus, influenza and parainfluenza 1 & 2 [3]

[1]JAMA Pediatr. 2017;171:573
[2]Epidemiol Infect 2007;135:262
[3]Journal of Infection 2006;52:37

CAP etiology

- Viruses most prevalent cause of CAP in childhood particularly during infancy
- RSV, influenza and human metapneumovirus most common viruses[1]
- *Strep. Pneumoniae* most common bacterial cause of CAP[1]
    - Incidence and severity of disease significantly reduced since introduction of pneumococcal conjugate vaccine[2]

[1] Thorax 2019;74:261 [2]Clin Infect Dis 2014;58:918

CAP etiology

- Less frequent causative bacterial pathogens include:
  - Group A streptococcal infection – associated with more severe illness particularly empyema[1]
  - *Staph. Aureus* – associated with an acute severe illness, pneumatocoeles and empyema
  - *Haemophilus influenzae* type b (Hib) was a frequent cause of CAP before Hib immunisation –still important in countries without universal vaccination[2]

- *Mycoplasma pneumonia* and *Chlamydia trachomatis* are a more common cause of CAP in older children[3]

[1]Can J Infect Dis 2014;25:151 [2]J Glob Health 2013;3:2013 [3]NEJM 2015;372:835

CAP clinical features

- No single symptom or sign is pathognomic for CAP in children
- May present with fever, cough, tachypnoea, breathlessness or difficulty in breathing, wheeze or chest pain
- May also present with abdo pain and/or vomiting +/- headache
- Large study of children hospitalised with CAP and CXR changes[1]:
  - 95% presented with cough, 90% fever, 75% anorexia, 70% short of breath

[1]NEJM 2015;372:835

CAP clinical features

- Tachypnoea
  - relatively specific but not sensitive[1]
  - associated with hypoxaemia in infants (>70 bpm)[2]
- Increased work of breathing
  - signs include grunting, nasal flaring and chest retractions or indrawing
  - highly specific for pneumonia[1]
- Chest examination
  - Crackles on auscultation
  - Wheeze more common with CAP due to atypical bacteria and viruses (also consistent with asthma and bronchiolitis)
  - Signs of consolidated lung including vocal resonance,vocal fremitus, reduced breath sounds, dullness to percussion

[1]JAMA 2017;318:426 [2]Ann Trop Paediatr 1998;18:31

CAP radiological investigations

- Chest radiographs in childhood CAP have a number of limitations:
  - findings do NOT correlate well with aetiologic agent[1]
  - have limited impact on therapeutic decisions
  - lateral views do not add diagnostic value
- Chest radiography should not be considered a routine investigation in children thought to have CAP
- Consider performing a Chest X-Ray (Antero-Posterior) particularly in those:
  - with hypoxaemia
  - with significant respiratory distress

[1]Thorax 2002;57:438

CAP general investigations

- Pulse oximetry provides a non-invasive, easy to use estimate of arterial oxygenation
  - hypoxaemia (<92% in air) indicates severe disease

- Acute phase reactants (C reactive protein, procalcitonin, white blood cell count)
  - raised levels associated with bacterial pneumonia but significant overlap with pneumonia of viral aetiology – therefore of little clinical utility[1]

[1]PIDJ 2008;27:95

CAP – microbiological investigations

- Microbiological diagnosis should be attempted in children with severe pneumonia sufficient to require paediatric intensive care admission or those with complications of CAP
- Microbiological investigations should not be considered routine in those with milder disease or those treated in the community
- Microbiological methods should include:
  - blood culture
  - nasopharyngeal and/or nasal swabs for PCR viral detection
  - acute and convalescent serology for viruses & atypical bacteria
  - pleural fluid for microscopy, culture and/or PCR

CAP – severity assessment

Features of Severe Pneumonia:

- Tachypnoea (>70 bpm under 12 months age, >50bpm over 12 months)
- Moderate/severe recession (<12 months)
- Severe difficulty breathing (>12 months)
- Grunting
- Nasal Flaring
- Apnoea (<12 months)
- Cyanosis
- Tachycardia (>170 bpm under 6 months, >160 bpm 6-12 months, >150 bpm 1-3 years, >140 3-5 years, >120 5-12 year, >100 over 12)
- Capillary Refill Time ≥ 2 secs
- Hypoxaemia (sustained oxygen saturation <92% in room air)
- Not feeding (< 12 months)
- Signs of dehydration (>12 months)

Adapted from BTS CAP in children guideline 2011

CAP – severity assessment

- Children with CAP in the community or hospital should be reassessed if symptoms persist and/or they are not responding to treatment
- Children with oxygen saturations <92% should be referred to hospital
- Auscultation revealing absent breath sounds with a dull percussion note should trigger a referral to hospital (?pneumonia with effusion)
- A child in hospital should be reassessed medically if there is persistence of fever 48 h after initiation of treatment, increased work of breathing or if the child is becoming distressed or agitated

CAP general management – hospital

- Antipyretics and analgesia as necessary
- Ventilatory support as required
  - patients whose oxygen saturations are ≤92% in air should receive oxygen to maintain saturations >95%
  - oxygen may be administered by nasal cannulae, face mask or high flow delivery device as necessary
- Children unable to maintain fluid intake due to breathlessness/fatigue should receive fluid therapy
  - avoid NG tubes particularly in severely ill patients and infants with small nasal passages
  - Baseline and daily monitoring of urea & electrolytes when on IV fluids
- Chest physiotherapy is not beneficial and should not be performed in children with pneumonia

CAP – antibiotic management

- All children with a clear clinical diagnosis of pneumonia should receive antibiotics as viral and bacterial pneumonia cannot be reliably distinguished from each other
- Amoxicillin is recommended as first choice for oral antibiotic therapy (alternatives are co-amoxiclav, cefaclor and macrolide antibiotics)
- Macrolide antibiotics may be added at any age if there is no response to first-line empirical therapy
- Macrolide antibiotics should be used if either mycoplasma or chlamydia pneumonia is suspected or in very severe disease
- Co-amoxiclav should be used for pneumonia associated with influenza

CAP – antibiotic management

- Antibiotics administered orally are safe and effective for children presenting with even severe CAP[1]
- Intravenous antibiotics should be used in the treatment of pneumonia in children when the child is unable to tolerate oral fluids or absorb oral antibiotics (eg because of vomiting) or presents with signs of septicaemia or complicated pneumonia
- Recommended intravenous antibiotics for severe pneumonia include amoxicillin, co-amoxiclav, cefuroxime and cefotaxime or ceftriaxone (local antibiotic guidelines should be consulted)

[1]Thorax 2007;62:1102

CAP – complications and failure to improve

- Pleural effusion and empyema
  - consider with fever beyond 7 days or not settling after 48 hours antibiotics[1]
  - CXR reveals fluid in pleural space; amount of fluid best estimated with ultrasound
  - if patient persistently febrile the pleural space should be drained
  - further details: BTS guidelines for the management of pleural infection in children[2]
- Necrotising pneumonia
  - characterised by necrosis and liquefaction of lung tissue
  - Usually 2^{o} to pneumococcus (particularly serotypes 3&19), *Staph. aureus* and group A *Streptococcus*[3]
  - Prolonged course of IV antibiotics often required

[1]Clin Infect Dis 2002;34:434 [2]Thorax 2005;60:i1 [3]Eur Resp J 2008;31:1285

CAP – complications and failure to improve

- Lung abscess
  - thick walled cavity within the lung tissue that contains purulent liquid
  - may be secondary to aspiration (especially in children with neurodevelopmental delay), congenital malformations and immunodeficiency
  - may result from inadequate or delayed treatment of lobar pneumonia
  - similar presentation to CAP initially but progresses indolently
  - mainstay of therapy is a prolonged course of parenteral antibiotics

CAP – prognosis and follow up

- Overall prognosis excellent with no long-term consequences
- Pneumonia mortality rate in developed countries is <1 per 1000 per year[1]
- Follow up not necessary for children with uncomplicated CAP who are asymptomatic - residual radiographic findings are rare and, even when present, do not result in additional therapy[2]
- Children with severe pneumonia, empyema and lung abscess should be followed up after discharge until they have recovered completely and their chest x-ray has returned to near normal

[1]Clin Infect Dis 2017;65:1721 [2]Ped Pulmonol 2005;40:223