Chapter 13
Thorax and Respiratory System

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Chest and Lungs

- The chest and lungs allow for respiration
- Purpose of respiration is to keep the body adequately supplied with oxygen and protected from excess accumulation of carbon dioxide
- Respiration involves:
  - Movement of air back and forth from the alveoli to the outside environment
  - Gas exchange across the alveolar-pulmonary capillary membranes
  - Circulatory system transport of oxygen to, and carbon dioxide from, the peripheral tissues

Anatomy and Physiology

Chest
- Chest or thorax, a cage of bone, cartilage, and muscle
  - Sternum
  - Manubrium
  - Xiphoid process
  - Twelve pairs of ribs connected to the thoracic vertebrae and to the sternum by the costal cartilages
- Primary muscles of respiration
  - Diaphragm
    - Primary muscle
    - Contracts during inspiration
  - External intercostal muscles
    - Increase the anteroposterior chest diameter during inspiration
- Sternocleidomastoid and trapezius accessory muscles
  - Brought into play when there are pulmonary problems and compromise

Chest (Cont.)
- Interior divided into three spaces
  - Mediastinum
  - Situated between lungs
  - Contains all thoracic viscera except the lungs
  - Right and left pleural cavities
  - Lined with parietal and visceral pleurae
  - Lungs enclosed by serous membrane

Lungs
- Highly elastic lungs paired but not symmetric
  - Right lung: three lobes
  - Left lung: two lobes and a lingula
- Lobes contain
  - Blood vessels
  - Lymphatics
  - Nerves
  - Alveolar ducts connecting with alveoli
  - Alveoli, as many as 300 million in adult
Tracheobronchial Tree
- Tubular system that provides a pathway along which air is filtered, humidified, and warmed
- Trachea lies anterior to the esophagus and posterior to the isthmus of the thyroid
- Divides into the right and left main bronchi at about the level of T4 or T5 and just below the manubriosternal joint
- The main bronchi are divided into three branches on the right and two on the left
- Right bronchus wider, shorter, and more vertically placed than the left bronchus (and therefore more susceptible to aspiration of foreign bodies)
- The branches then begin to subdivide into terminal bronchioles and ultimately into respiratory bronchioles where gas exchange takes place
- The bronchial arteries branch from the anterior thoracic aorta and the intercostal arteries, supplying blood to the lung parenchyma and stroma
- Bronchial vein is formed at the hilum of the lung
- Most of the blood supplied by the bronchial arteries is returned by the pulmonary veins

Anatomic Landmarks
- Topographic markers
  - Nipples (usually 4th intercostal space for males; more variable for females)
  - Manubriosternal junction (2nd intercostal space)
  - Suprasternal notch
  - Costal angles
  - Vertebra prominens
  - Spinous process of C7 or T1
  - Clavicles (apex of the lung partially above the clavicles)

Infants and Children
- Fetal lungs contain no air; gas exchange is through placenta
- At birth, lungs adapt to postnatal function
  - Relative decrease in pulmonary pressure most often leads to closure of the foramen ovale within minutes after birth
  - Increased oxygen tension in the arterial blood usually stimulates contraction and closure of the ductus arteriosus
- Reminder: The foramen ovale and the ductus arteriosus do not always close so readily

Infants and Children (Cont.)
- Chest of the newborn is generally round
- Chest circumference is same as head circumference until about 2 years of age—why would a child have a barrel chest?
- With growth, the chest assumes adult proportions, with the lateral diameter exceeding the anteroposterior diameter
- Chest wall is thinner and bony structures more prominent and yielding than in adults

Pregnant Women
- Mechanical and biochemical factors lead to changes in respiratory function
  - Enlarging uterus
  - Increased progesterone
- Anatomic changes in chest
  - Lower ribs flare
  - Diaphragm rises above usual position
  - Diaphragm movement increases so that major work of breathing is done by diaphragm
  - Minute ventilation increases due to increased tidal volume
  - Respiratory rate usually remains unchanged, unless pain alters

Older Adult
- Barrel chest from loss of muscle strength in thorax and diaphragm and loss of lung resiliency
- Skeletal changes emphasizing dorsal curve of thoracic spine
- Alveoli less elastic, causing fatigue and dyspnea on exertion
- Decrease in vital capacity/increase in residual volume
- Mucous membranes drier
History of Present Illness

- Coughing
  - Onset
  - Nature of cough
  - Sputum production
  - Sputum characteristics
  - Pattern
  - Severity
  - Associated symptoms
  - Efforts to treat

- Sputum
  - The production of sputum is generally associated with cough
  - Describe
    - Color (Spectrum from ______ to ______)
    - Consistency (Spectrum from thin to thick)
    - Odor

- History of Present Illness (Cont.)
  - Chest pain
    - Onset and duration
    - Associated symptoms
    - Efforts to treat
    - Other medications
      - Illicit drugs (e.g., cocaine)

Coughs

- Describe
  - Dry or moist
  - Onset (Gradual or sudden? How long? Precipitating event(s)?)
  - Frequency of occurrence
  - Regularity
  - Pitch and loudness
  - Postural influences
  - Quality

Sputum

- Describe
  - Color (Spectrum from ______ to ______)
  - Consistency (Spectrum from thin to thick)
  - Odor

History of Present Illness (Cont.)

- Shortness of breath
  - Onset
  - Pattern
  - Position most comfortable, number of pillows used
  - Related to extent of exercise, certain activities, time of day, eating
    - Harder to inhale or exhale
    - Severity
    - Associated symptoms
    - Efforts to treat

Past Health History

- Thoracic trauma or surgery, dates of hospitalization for pulmonary disorders
- Use of oxygen and ventilation-assisting devices
  - CPAP or BiPAP
- Chronic pulmonary diseases
- Other chronic disorders
- Testing
- Immunization against *Streptococcus pneumoniae*, influenza
Family History
- Tuberculosis (TB)
- Cystic fibrosis
- Emphysema
- Allergy, asthma, atopic dermatitis
- Malignancy
- Bronchiectasis
- Bronchitis
- Clotting disorders (risk of pulmonary embolism and ________)

Personal and Social History
- Employment
- Home environment
- Tobacco use
- Exposure to respiratory infections, influenza, TB
- Nutritional status
- Use of complementary and alternative therapies
- Regional/travel exposures
- Hobbies
- Use of alcohol/drugs
- Exercise tolerance

Infants and Children
- Low birth weight and prematurity
- Coughing and sudden-onset shortness of breath
- Possible ingestion of kerosene, antifreeze, or hydrocarbons in household cleaners
- Apneic episodes; use of apnea monitor
- Swallowing dysfunction
  - Gastroesophageal reflux
- History of pneumococcal and influenza vaccination

Pregnant Women
- Weeks of gestation
- Presence of multiple fetuses, polyhydramnios, other conditions in which uterus displaces diaphragm
- Exercise type and energy expenditure
- Exposure to and frequency of respiratory infections

Older Adults
- Exposure and frequency of respiratory infections
  - History of pneumococcal and flu vaccine
- Need for supplemental oxygen
- Effects of weather on respiratory efforts and infection occurrence
- Immobilization and sedentary habits
- Difficultly swallowing
- Altered activities from respiratory symptoms
  - Emphasize
    - Smoking history
    - Cough
    - Dyspnea on exertion or breathlessness
    - Fatigue
    - Weight changes
    - Fever and night sweats

Examination and Findings
Equipment

- Marking pen
- Centimeter ruler and tape measure
- Stethoscope with bell and diaphragm (for infants, you will need a smaller stethoscope)
- Drapes

Order of the Examination

- None of the following examinations are invasive—so why is the order important?
- 1. Inspection
- 2. Palpation
- 3. Percussion
- Diaphragmatic excursion
- 4. Auscultation
- NO EXAM SHOULD BE INTERPRETED IN ISOLATION OF THE HISTORY AND OTHER EXAM FINDINGS

Inspection

- Chest
  - Shape and symmetry
  - Chest wall movement
  - Superficial venous patterns
  - Prominence of ribs
  - Anteroposterior vs. transverse diameter
    - Barrel chest
    - Sternal protrusion
    - Spinal deviation

Inspection (Cont.)

- Peripheral clues may suggest pulmonary or cardiac difficulties
  - Fingers: clubbing
  - Breath: odor
  - Skin, nails, and lips: cyanosis or pallor
  - Lips: pursing
  - Nostrils: flaring
Inspection (Cont.)
- Respiration
  - Rate
    - 12 to 20 breaths/minute in resting adult
  - Rhythm
  - Kussmaul breathing
  - Pattern
    - Cheyne-Stokes
    - Biot respiration
  - Count rate while palpating pulse

Observing Respiration
- Inspect the chest wall movement during respiration
- Symmetry
- Retractions are when the chest wall seems to cave in at the sternum, between the ribs, at the suprasternal notch, above the clavicles, and at the lowest costal margins
  - Suggests an obstruction to inspiration at any point in the respiratory tract
- Paradoxic breathing: On inspiration, the lower thorax is drawn in, and on expiration, the opposite occurs

Clues in Periphery
- Lips and nails for cyanosis
- Pursing of the lips
- Clubbing (enlargement of the terminal phalanges of the fingers or toes)
- Flaring of alae nasi
- Odor of breath
- Supernumerary nipples
- Superficial venous patterns on chest

Palpation
- The following are findings possible any time you have your hands on the patient’s thorax—not specific exam techniques
  - Thoracic muscles/skeleton
  - Pulsations
  - Tenderness
  - Bump/depressions
  - Masses
  - Unusual movement/positions
  - Elasticity of rib cage
  - Immovability of sternum
  - Rigidity of thoracic spine

Palpation (Cont.)
- Crepitus
  - Crackle or crinkly sensation, can be both palpated and heard
  - Indicates air in the subcutaneous tissue
  - Rupture somewhere in the respiratory system
  - Infection with a gas-producing organism
- Friction rub
  - Palpable, coarse, grating vibration, usually on inspiration
  - Name three “F” structures in the body that might produce friction rubs
Palpation (Cont.)

- Thoracic expansion
  - Loss of symmetry in the movement of the thumbs suggests a problem on one or both sides
- Tactile fremitus
  - Palpable vibration of the chest wall that results from speech or other verbalizations
- Note the position of the trachea
  - Deviation—what are possible causes of tracheal deviation?

Percussion (Cont.)

- Percuss chest
  - Anterior (limited exam due to density of pectoralis muscles and breasts)
  - Lateral
  - Posterior
- Compare tones bilaterally
- Measure diaphragmatic excursion
  - Diaphragm usually higher on right (liver)
  - Descent may be limited by pathologic processes

Percussion

- Percussion tone indicators for lungs
  - Resonance is expected
  - Hyper-resonance indicates hyperinflation
  - Dullness indicates diminished air exchange

Auscultation

- Auscultation with a stethoscope provides important clues to the condition of the lungs and pleura
- All sounds can be characterized in the same manner as the percussion notes:
  - Intensity/Volume
  - Pitch
  - Quality
  - Duration

Normal Breath Sounds—depending on location

- Vesicular
  - Low-pitched, low-intensity sounds heard over healthy lung tissue
- Bronchovesicular
  - Moderate-pitched, moderate-intensity heard over the major bronchi
- Bronchial
  - High-pitched, high-intensity heard over largest airway—trachea
  - Sometimes called "tracheal breath sounds"
- Both bronchovesicular and bronchial breath sounds are abnormal if they are heard over the peripheral lung tissue

Breath Sounds (Cont.)

- Amphoric
  - Breathing that resembles the noise made by blowing across the mouth of a bottle
  - Most often heard with a large, relatively stiff-walled pulmonary cavity or a tension pneumothorax with bronchopleural fistula
- Cavernous
  - Sounding as if coming from a cave
  - Commonly heard over a pulmonary cavity in which the wall is rigid
Breath Sounds (Cont.)

- Adventitious breath sounds
  - Crackles (formerly called rales)
    - Abnormal respiratory sound heard more often during inspiration and characterized by discrete discontinuous sounds
    - Fine: high-pitched, and relatively short in duration
    - Coarse: low-pitched, and relatively longer in duration

Breath Sounds (Cont.)

- Adventitious breath sounds (cont.)
  - Wheezes (sibilant wheezes)
    - Continuous, high-pitched, musical sound (almost a whistle) heard during inspiration or expiration
    - Caused by a relatively high-velocity air flow through a narrowed or obstructed airway
    - May be caused by the bronchospasm of asthma (reactive airway disease) or acute or chronic bronchitis

Breath Sounds (Cont.)

- Adventitious breath sounds (cont.)
  - Rhonchi (sonorous wheezes)
    - Deeper, more rumbling, more pronounced during expiration, more likely to be prolonged and continuous, and less discrete than crackles
    - Caused by the passage of air through an airway obstructed by thick secretions, muscular spasm, new growth, or external pressure

Breath Sounds (Cont.)

- Adventitious breath sounds (cont.)
  - Friction rub
    - Occurs outside the respiratory tree
    - Dry, crackly, grating, low-pitched sound and is heard in both expiration and inspiration
    - Caused by inflamed, roughened surfaces rubbing together

Breath Sounds (Cont.)

- Adventitious breath sounds (cont.)
  - Mediastinal crunch (Hamman sign)
    - Found with mediastinal emphysema
    - Variety of sounds—loud crackles, clicking and gurgling sounds are synchronous with the heartbeat and not particularly so with respiration

Vocal Resonance (extra eval)

- Spoken voice transmits sounds through the lung fields that may be heard with the stethoscope

- The following auditory changes may be present in any condition that consolidates lung tissue
  - Bronchophony
  - Pectoriloquy
  - Egophony

- Conversely, vocal resonance diminishes and loses intensity when there is loss of tissue within the respiratory tree (e.g., with the barrel chest of emphysema)
Vocal Resonance (Cont.)

- Bronchophony
  - Greater clarity and increased loudness of spoken sounds
- Pectoriloquy
  - Extreme bronchophony where even a whisper can be heard clearly through the stethoscope
- Egophony
  - Intensity of the spoken voice is increased and there is a nasal quality
  - a’s become stuffy nasal a’s

Infants

- Examination approach is similar to that in adults; percussion is less reliable in infants
- Inspect the thoracic cage, noting size and shape
- Measure the chest circumference
  - Usually 2 to 3 cm smaller than the head circumference
- Respiratory rate varies between 40 and 60 respirations per minute
- Periodic breathing, a sequence of relatively vigorous respiratory efforts followed by apnea of as long as 10 to 15 seconds, is common

Infants (Cont.)

- Coughing is rare; sneezing is frequent
- Hiccups are also frequent
- At first, breathing is primarily diaphragmatic; use of intercostal muscles is gradual
- Paradoxic breathing (the chest wall collapses as the abdomen distends on inspiration) is common, particularly during sleep

Infants (Cont.)

- Palpate the clavicle, rib cage, and sternum, noting loss of symmetry, unusual masses, or crepitus
- Listen to the chest
  - Breath sounds are easily transmitted from one segment of the auscultatory area to another
  - Localization of breath sounds can be difficult
  - Absence of sounds in any given area may be difficult to detect

Infants (Cont.)

- Stridor
  - High-pitched, piercing sound most often heard during inspiration
  - Result of an obstruction high in the respiratory tree
- Respiratory grunting
  - Mechanism by which the infant tries to expel trapped air or fetal lung fluid while trying to retain air and increase oxygen levels
  - Cause for concern if persistent
- Flaring of the alae nasi
  - Another indicator of respiratory distress

Children

- Children use the thoracic (intercostal) musculature for respiration by the age of 6 or 7 years
- Variable respiratory rate, decreasing with age, reaching adult rates at about 17 years
- Roundness of chest persisting past second year is a possible indication of a pulmonary problem
- The younger the infant or toddler, the more difficult to evaluate wheezing
Children (Cont.)
- Child’s chest is thinner and ordinarily more resonant than the adult’s chest
- Breath sounds
  - More resonant
  - Hyperresonance common
  - Easy to miss dullness
  - Bronchovesicular sounds may predominate

Pregnant Women
- Pregnant women experience both structural and ventilatory changes
- Dyspnea is common in pregnancy and is usually a result of normal physiologic changes
- Overall, the pregnant woman increases her ventilation by breathing more deeply, not more frequently

Older Adults
- Chest expansion decreased
- Respiratory muscle weakness
- General physical disability
- Sedentary lifestyle
- Calcification of rib articulations
- Bony prominences marked
- Kyphosis with flattening of lumbar curve
- Increased anteroposterior diameter
- Hyperresonance common

Abnormalities
- Asthma (reactive airway disease)
  - Small airway obstruction due to inflammation and hyper-reactive airways
- Atelectasis
  - Incomplete expansion of the lung at birth or the collapse of lung segment(s) at any age
- Bronchitis
  - Inflammation of the large airways

Normal Chest X-rays
5 years ago  Current

<table>
<thead>
<tr>
<th>Abnormalities (Cont.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pleurisy</strong></td>
</tr>
<tr>
<td>Inflammatory process involving the visceral and parietal pleura, which becomes edematous and fibrinous</td>
</tr>
<tr>
<td><strong>Pleural effusion</strong></td>
</tr>
<tr>
<td>Excessive nonpurulent fluid in the pleural space</td>
</tr>
<tr>
<td><strong>Empyema</strong></td>
</tr>
<tr>
<td>Purulent exudative fluid collected in the pleural space</td>
</tr>
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| Pleural effusion—imagine how this obstructs sound and vibration |

<table>
<thead>
<tr>
<th>Abnormalities (Cont.)</th>
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<tbody>
<tr>
<td><strong>Pneumothorax</strong></td>
</tr>
<tr>
<td>Presence of air or gas in the potential space of the pleural cavity</td>
</tr>
<tr>
<td><strong>Hemothorax</strong></td>
</tr>
<tr>
<td>Presence of blood in the pleural cavity</td>
</tr>
<tr>
<td><strong>Lung cancer</strong></td>
</tr>
<tr>
<td>Generally refers to bronchogenic carcinoma, a malignant tumor that evolves from bronchial epithelial structures</td>
</tr>
</tbody>
</table>

| Pneumothorax |

| Hemothorax |

Abnormalities (Cont.)

- Lung abscess
  - Well-defined, circumscribed mass defined by inflammation, suppuration, and subsequent central necrosis

- Pneumonia
  - Inflammatory response of the bronchioles and alveoli to an infective agent (bacterial, fungal, or viral)

Bacterial pneumonia

Influenza (H5N1)
Abnormalities (Cont.)

- Influenza
  - Viral infection of the lung
  - Normally an upper respiratory infection, but due to alterations in the epithelial barrier, the infected host is more susceptible to secondary bacterial infections

- Tuberculosis
  - Chronic infectious disease that most often begins in the lung but may then have widespread manifestations

Abnormalities (Cont.)

- Pulmonary embolism
  - Embolic occlusion of pulmonary arteries
  - Relatively common condition
  - Difficult to diagnose

Infants, Children, and Adolescents

- Diaphragmatic hernia
  - Result of an imperfectly structured diaphragm, occurs once in slightly more than 2000 live births

- Cystic fibrosis
  - Autosomal recessive disorder of exocrine glands involving the lungs, pancreas, and sweat glands

- Epiglottitis
  - Acute life-threatening infection involving the epiglottis and surrounding tissues—produces what characteristic sound?

- Croup (laryngotracheal bronchitis)
  - Syndrome that generally results from infection with a variety of viral agents, particularly the parainfluenza viruses occurring most often in children from about 1.5 to 3 years of age—sound?

- Tracheomalacia
  - Lack of rigidity or a floppiness of the trachea or airway

- Bronchiolitis
  - Inflammation of the small airways leading to hyperinflation of the lungs occurring most often in infants younger than 6 months

Cystic fibrosis

Epiglottitis
Older Adults

- Chronic obstructive pulmonary disease
  - COPD is a nonspecific designation that includes a group of respiratory problems in which cough, chronic and often excessive sputum production, and dyspnea are prominent features.
  - Not limited to older adults; smokers at greatest risk.
  - Emphysema, bronchiectasis, and chronic bronchitis are the main conditions that are included in this group.

Older Adults (Cont.)

- Emphysema
  - Condition in which the lung s lose elasticity and alveoli enlarge in a way that disrupts function.

- Bronchiectasis
  - Chronic dilation of the bronchi or bronchioles is caused by repeated pulmonary infections and bronchial obstruction.

- Chronic bronchitis
  - Large airway inflammation, usually a result of chronic irritant exposure, more commonly a problem for patients older than 40.

Emphysema

- Emphysema
  - Condition in which the lungs lose elasticity and alveoli enlarge in a way that disrupts function.

Bronchiectasis

- Bronchiectasis
  - Chronic dilation of the bronchi or bronchioles is caused by repeated pulmonary infections and bronchial obstruction.

Some Causes of Sputum

<table>
<thead>
<tr>
<th>Cause</th>
<th>Possible Sputum Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacterial infection</td>
<td>Yellow, green, rust (blood mixed with yellow sputum), clear or transparent, purulent, blood streaked, sticky</td>
</tr>
<tr>
<td>Malaria infection</td>
<td>Blood streaked (not common)</td>
</tr>
<tr>
<td>Chronic infectious disease</td>
<td>All of the above, particularly abundant in the early morning; slight intermittent blood streaking; occasionally, large amounts of blood</td>
</tr>
<tr>
<td>Cancer</td>
<td>Slight, persistent, intermittent blood streaking</td>
</tr>
<tr>
<td>Infection</td>
<td>Blood clotted; large amounts of blood</td>
</tr>
<tr>
<td>Tuberculous cavity</td>
<td>Occasional large amounts of blood</td>
</tr>
</tbody>
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Percussion Tones Heard over the Chest

<table>
<thead>
<tr>
<th>Type of Tone</th>
<th>Intensity</th>
<th>Pitch</th>
<th>Duration</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resonant</td>
<td>Loud</td>
<td>Low</td>
<td>Long</td>
<td>Hollow</td>
</tr>
<tr>
<td>Flat</td>
<td>Soft</td>
<td>High</td>
<td>Short</td>
<td>Very dull</td>
</tr>
<tr>
<td>Dull</td>
<td>Medium</td>
<td>Medium to high</td>
<td>Medium</td>
<td>Dull thud</td>
</tr>
<tr>
<td>Tympanic</td>
<td>Loud</td>
<td>High</td>
<td>Medium</td>
<td>Drumlike</td>
</tr>
<tr>
<td>Hyperresonant</td>
<td>Very loud</td>
<td>Very low</td>
<td>Longer</td>
<td>Booming</td>
</tr>
</tbody>
</table>