THE PHYSICAL DIAGNOSIS OF COMMON PLEURAL AND PULMONARY SYNDROMES
Anatomy & physiology

**Anatomy**: be able to **number ribs** and intercostal spaces!

**Anteriorly**: 5 cm down from suprasternal notch are:
- sternal angle and 2nd (below is the 2nd interspace)
- walk down the interspaces with 2 fingers
- 1st to 7th ribs articulate to sternum
- 8th to 10th ribs articulate to cartilages (just above)
- 11th and 12th are floating ribs

**Posteriorly**: walk upward from 12th or 11th ribs
- the angle of scapula is above 7th rib (or interspace)
- *Vertebra prominens* belongs to 7th cervical and processes are countable below it

**Lines on the thorax**: midsternal, midclavicular, anterior and posterior axillary, midaxillary, scapular, vertebral

- Trachea bifurcates under sternal angle or behind 4th thoracic spinous process

**Physiology**: Active muscle movement by the diaphragm, parasternal, intercostal, and neck muscles. Lungs expand passively.
Anatomy of the chest and lungs
Lines on the thorax

- Midsternal line
- Left midclavicular line (vertical from the midpoint of the clavicle)
- Left anterior axillary line (vertical from the anterior axillary fold)
- Scapular line (vertical from the inferior angle of the scapula)
- Vertebral line (along the spinous processes)
- Anterior axillary line
- Midaxillary line (vertical from the apex of the axilla)
- Posterior axillary line (vertical from the posterior axillary fold)
Techniques of examination

In general: The patient should undress. Order: inspect, palpate, percuss, auscultate. Compare one side to the other (own control). Try to visualize underlying tissues. Sitting and supine position (roll patient on one side)

Survey:
- Color (cyanosis). Shape of fingernails (clubbing)
- Inspect neck (additional muscle effort). Listen to patient's breathing. Observe the shape of the thorax (barrel chest).

Deformities of thorax:
- Normally wider than deep. Barrel chest (aging, chronic obstructive disease, emphysema), traumatic fail chest, funnel chest (pectus excavatum, murmurs by heart: compression), pigeon chest (pectus carinatum), thoracic kyphoscoliosis

Palpation of thorax: To identify tender areas. Assessment of observed abnormalities (masses, sinus tracts). Assessment of respiratory expansions. Assessment of tactile fremitus (palpable transmitted vibrations). Palpate symmetrical areas.

Percussion: Whether the underlying tissues are air-filled, fluid-filled, or solid. No information about deep-seated lesions. Identify the level of diaphragmatic dullness. Estimate diaphragmatic excursion
<table>
<thead>
<tr>
<th></th>
<th>Intensity</th>
<th>Pitch</th>
<th>Duration</th>
<th>Example</th>
<th>Pathologic examples</th>
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<tr>
<td>Flatness</td>
<td>soft</td>
<td>high</td>
<td>short</td>
<td>Thigh</td>
<td>Pleural effusion</td>
</tr>
<tr>
<td>Dullness</td>
<td>medium</td>
<td>medium</td>
<td>medium</td>
<td>Liver</td>
<td>Lobar pneumonia</td>
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<tr>
<td>Resonance</td>
<td>loud</td>
<td>low</td>
<td>long</td>
<td>Normal lung</td>
<td>Bronchitis, asthma bronchiale</td>
</tr>
<tr>
<td>Hyperresonance</td>
<td>very loud</td>
<td>lower</td>
<td>longer</td>
<td>Abnormal lung</td>
<td>Emphysema PTX</td>
</tr>
<tr>
<td>Tympany</td>
<td>loud</td>
<td>high</td>
<td></td>
<td>Gastric air bubble</td>
<td>Large PTX</td>
</tr>
</tbody>
</table>
**BREATH SOUNDS**

**Vesicular breathing.** Quiet respiration produces a soft, low-pitched noise. The inspiratory phase is longer, no pause between insp. and exp. Can be heard over the entire lung surface, except beneath the manubrium sterni and the upper interscapular region. Origin: distal from the trachea but proximal from the alveoli.

**Bronchial breathing (tubular breathing).** Is louder, higher-pitched, expiratory phase is longer, short pause between insp. and esp. Can be heard over the trachea (suprasternal notch and the 6th-7th cervical spines). Does not occur in the normal lung, it results from consolidation or compression of pulmonary tissue that facilitates transmission of sound from the bronchial tree.

**Bronchovesicular breathing.** Intermediate. Normally heard at the manubrium sterni and in the upper interscapular region. In other parts it is pathological and indicates a small degree of consolidation or compression of lung tissue that transmits sounds from the bronchial tree.

**Tracheal breathing.** Is very loud, high-pitched.

**Asthmatic breathing.** Short inspiration, long, forced expiration, often accompanied by musical rales.

**Amphoric breathing.** Occurs when air blows over the mouth of a bottle. In the lungs it is produced by a large empty cavity that communicates with a bronchus or an open pneumothorax. *Cavernous breathing* - low-pitched and hollow sound.
Note:

• The ear can be trained to recognize sounds more accurately.
• Look for patterns of pitch and overtones!
• Find a quiet place for auscultation.
DISTINGUISHING FEATURES OF BREATH SOUNDS

Vesicular
Bronchovesicular
Bronchial

Cogwheel breathing
Asthmatic breathing

De Gowin and De Gowin. Bedside Diagnostic Examination
Map of breath sounds in the normal chest

De Gowin and De Gowin: Bedside Diagnostic Examination
Rate and rhythm abnormalities of breathing

• Normally 14-20/min in adults, up to 44/min in infants.
• **Tachypnea**: rapid, shallow breathing. Occurs in restrictive lung diseases, pleuritic pain, elevated diaphragm.
• **Hyperpnea or hyperventilation**: rapid deep breathing. Occurs during exercise, anxiety, hypoxia, in comatose patient affecting midbrain or pons, metabolic acidosis (Kussmaul breathing is deep with different rate).
• **Bradypnea**: slow breathing. Occurs in drug-induced breathing depression, diabetic coma, increased intracranial pressure.
• **Cheyne-Stokes breathing**: deep breathing alternates with periods of apnea. Occurs in heart failure, uremia, drug-induced respiratory depression, brain damage.
• **Ataxic breathing (Biot’s breathing)**: unpredictable irregularity in brain damage, respiratory depression.
• **Sighing respiration**: punctuated by frequent sighs in hyperventilation syndrome.
Special maneuvers:

- Simple walk with the patient (maybe upstairs) to observe rate, regularity, depth, and effort of breathing.
- Forced expiratory time longer than 5 sec in obstructive diseases.

Voice sounds.

- *Pectoral fremittus (tactile fremittus, pectoriloquy).* Palpation of the vibration chest wall generated by whispered or spoken words. Increased in consolidation, decreased in pleural effusion.
- *Bronchophony.* Ask patient to say „ninety-nine” or „one-two-three” and listen to symmetrical areas.
Added lung sounds

**Origin**
- Alveoli
  - "Crepitation" heard only in inspiration
- Bronchi
- Rales
- Pleura or pericardium
- Main airway obstruction
- Rub (inflammation)
- Stridor

**Moist crepitations**
- Fine
- Medium
- Coarse

**Dry**
- Wheezing
- Ronchi
<table>
<thead>
<tr>
<th>Disorder</th>
<th>Inspection</th>
<th>Palpation</th>
<th>Percussion</th>
<th>Auscultation</th>
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</thead>
<tbody>
<tr>
<td>Bronchial asthma (acute attack)</td>
<td>Hyperinflation (use of accessory muscles)</td>
<td>Impaired expansion; decreased fremitus</td>
<td>Hyperresonant; low diaphragm</td>
<td>Prolonged expiration; inspiratory and expiratory wheezes</td>
</tr>
<tr>
<td>Pneumothorax (complete)</td>
<td>Lag on affected side</td>
<td>Absent fremitus</td>
<td>Hyperresonant or tympanic</td>
<td>Absent breath sounds</td>
</tr>
<tr>
<td>Pleural effusion (large)</td>
<td>Lag on affected side</td>
<td>Decreased fremitus; trachea and heart shifted away from affected side</td>
<td>Dullness or flatness</td>
<td>Absent breath sounds</td>
</tr>
<tr>
<td>Atelectasis (lobar obstruction)</td>
<td>Lag on affected side</td>
<td>Decreased fremitus; trachea and heart shifted toward affected side</td>
<td>Dullness or flatness</td>
<td>Absent breath sounds</td>
</tr>
<tr>
<td>Consolidation (pneumonia)</td>
<td>Possible lag or splinting on affected side</td>
<td>Increased fremitus</td>
<td>Dullness</td>
<td>Bronchial breath sounds; bronchophony; pectoriloquy; crackles</td>
</tr>
</tbody>
</table>
## THORACIC DISORDERS WITH DULLNESS AND DIMINISHED VIBRATION

<table>
<thead>
<tr>
<th></th>
<th>Small pleural effusion</th>
<th>Pleural thickening</th>
<th>Consolidation and bronchial plug</th>
<th>Atelectasis and bronchial plug</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tracheal deviation</td>
<td>O</td>
<td>O or ←</td>
<td>O</td>
<td>←</td>
</tr>
<tr>
<td>Fremitus</td>
<td>V or O</td>
<td>V</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Percussion</td>
<td>dull</td>
<td>dull</td>
<td>dull</td>
<td>dull</td>
</tr>
<tr>
<td>Breath sounds</td>
<td>V</td>
<td>V</td>
<td>V or O</td>
<td>O</td>
</tr>
<tr>
<td>Whisper sounds</td>
<td>V</td>
<td>V</td>
<td>V or O</td>
<td>O</td>
</tr>
<tr>
<td>Voice sounds</td>
<td>V</td>
<td>V</td>
<td>V or O</td>
<td>O</td>
</tr>
<tr>
<td>Rales</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>

**Legend:** O = absent; V = diminished, ← = direction of deviation
Added lung sounds

Origin

Alveoli
- "Crepitation" heard only in inspiration

Bronchi

Pleura or pericardium
- Rub (inflammation)

Main airway obstruction

Rales

Stridor

moist crackles

fine

medium

course

dry

wheezing

ronchi
Pleural friction rub

- Caused by loss of lubricating fluid due to inflammation of the pleura so the opposing surfaces rub together. Can be imitated by firmly rubbing the thumb against the forefinger near the ear. Can repeatedly be delayed by increased friction. Disappears when surfaces are separated by fluid.
Pleural fluid (Hydrothorax)

- Dull, flat note to percussion. The lung immediately over the fluid may be hyperresonant. Distribution is typical to fluid. The trachea may be pushed to the unaffected side. Vocal fremitus is absent.
- **Distinction:** from consolidation (by displacement of the trachea), and, if necessary, thoracocentesis.
- **Definition:** any liquid is called "fluid". It can be clear (transudate or exudate), purulent (pyothorax, or empyema thoracis), bloody (haemothorax), chylous (chylothorax).
Pleural effusion

- homogeneously increased density above the diaphragm and adjacent to the chest wall. Lateral view is also needed.
Large pleural effusion
Classification of pleural fluid

**TRANSUDATE**
- Specific gravity: < 1015, Rivalta: negative, protein content < 30 g/l, LDH: < 200 U/l, pleural/serum protein < 0.5 and pleural/serum LDH < 0.6.
- **Occurrence:** Congestive heart failure, nephrotic syndrome, portal vein obstruction, Meigs’ syndrome

**EXUDATE**
- Specific gravity: > 1015, Rivalta: positive, protein content > 30 g/l, LDH: > 200 U/l, pleural/serum protein > 0.5 and pleural/serum LDH > 0.6.
- **Occurrence:** Pneumonia, tuberculosis, malignancy, pulmonary embolism.
Exudate

Clear:
  • Predominance of granulocytes: Bacterial pneumonia, pulmonary infarction, rheumatic fever, RA (glucose < 1.1 mM/l), Coxsackie A virus infection, SLE, scleroderma
  • Predominance of lymphocytes: Tuberculosis, sarcoidosis, fungal infections, myxedema, carcinoma
  • Predominance of eosinophils: Hodgkin’s disease echinococcal (hydatid) infection, RA, Löffler’s syndrome, polyarteritis nodosa

Cloudy exudate: Same as for clear exudates.

Blood-tinged exudate: Carcinoma, mesothelioma, pulmonary infarction, hemopneumothorax, tuberculosis, Coxsackie A virus infection, hemorrhagic pancreatitis, strangulated omentum in diaphragmatic hernia

Brown exudates (from degenerating erythrocytes): Cancer, pulmonary embolism, amebic liver abscess, old cholesterol effusions

Red blood: Trauma, contusion, hemopneumothorax, cancer, pulmonary embolism

Chylous: Disruption or obstruction of thoracic duct, empyema, lymphoma

Recurrent bilateral effusions: Asbestosis, drug sensitivity: nitrofurantoin, chemotherapeutic drugs, methylsergide
COMMON CAUSES OF PLEURAL EFFUSION

- Malignancy
- Congestive heart failure
- Peritoneal dialysis
- Pulmonary infarction
- Infection (bacterial, fungal, parasitic, tuberculous, viral)
- Pancreatitis
- Cirrhosis with ascites
- Collagen diseases
- Renal diseases (nephrotic syndrome)
- Subphrenic abscess
- Trauma to lung, mediastinum, or spine
- Postmyocardial infarction (Dressler's syndrome)
- Postcardiac injury
- Idiopathic
Dullness with diminished vibrations

Atelectasis with bronchial plug

- The volume of the atelectatic lung is diminished. The dense mass is pulled toward the chest wall by negative pressure. Increased density of collapsed lung causes dullness. The bronchial plug prevents vibration, so vocal fremitus, breath sounds, whispered, or spoken voice are absent.

- **Occurrence**: bronchogenic tumor, extrabronchial compression by lymph nodes, postoperatively, foreign bodies, following radiotherapy.

Pulmonary consolidation with bronchial plug

- The consolidated lung produces dullness. A bronchial plug prevents vibrations of the air column → absence of vocal fremitus, breath sounds, whispered, or spoken voice. The trachea is not displaced.

- **Occurrence**: temporarily in lobar pneumonia.
Atelectasis
**THORACIC DISORDERS WITH DULLNESS AND ACCENTUATED VIBRATION**

- **Small consolidation**
  - Tracheal deviation: N or \( \downarrow \)
  - Fremitus: N or \( \downarrow \)
  - Percussion: slight dullness
  - Breath sounds: broncho-vesicular or bronchial
  - Whisper sounds: N, O, or \( \downarrow \)
  - Voice sounds: N, O, or \( \downarrow \)
  - Rales: + or O

- **Thick-walled cavity**
  - Tracheal deviation: N or \( \downarrow \)
  - Fremitus: N or \( \downarrow \)
  - Percussion: slight dullness
  - Breath sounds: broncho-vesicular or amphoric
  - Whisper sounds: pectoriloqui
  - Voice sounds: pectoriloqui
  - Rales: +

- **Massive consolidation**
  - Tracheal deviation: N or \( \downarrow \)
  - Fremitus: \( \uparrow \)
  - Percussion: dull or flat
  - Breath sounds: bronchial
  - Whisper sounds: pectoriloqui
  - Voice sounds: pectoriloqui
  - Rales: +

- **Large pleural effusion**
  - Tracheal deviation: \( \rightarrow \)
  - Fremitus: N or \( \downarrow \)
  - Percussion: (a) hyper-resonant, (b) flat
  - Breath sounds: O or loud bronchial
  - Whisper sounds: O or \( \downarrow \)
  - Voice sounds: O or \( \downarrow \)
  - Rales: +

Legend: O = absent; N = normal; \( \uparrow \) = increased; \( \leftarrow \) = direction of deviation
X-ray of the normal chest
Pneumonia
## THORACIC DISORDERS WITH RESONANCE AND IMPAIRED VIBRATION

<table>
<thead>
<tr>
<th>Tracheal deviation</th>
<th>Pulmonary emphysema</th>
<th>Closed pneumothorax</th>
<th>Open pneumothorax</th>
<th>Hydro-pneumo-thorax</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>O</td>
<td>→</td>
<td>→</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fremitus</th>
<th>O</th>
<th>O</th>
<th>O</th>
<th>O</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>hyper-resonant</td>
<td>resonant or hyper</td>
<td>hyper-resonant</td>
<td>(a) hyperresonant</td>
<td>(b) flat</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Percussion</th>
<th>O</th>
<th>O</th>
<th>O</th>
<th>O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breath sounds</td>
<td>V or O</td>
<td>V or O</td>
<td>V or O</td>
<td>O</td>
</tr>
<tr>
<td>Whisper sounds</td>
<td>V or O</td>
<td>V or O</td>
<td>V or O</td>
<td>O</td>
</tr>
<tr>
<td>Voice sounds</td>
<td>V or O</td>
<td>V or O</td>
<td>V or O</td>
<td>O</td>
</tr>
<tr>
<td>Rales</td>
<td>+ or O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td>coin sound</td>
<td>coin sound</td>
<td>coin sound, succussion splash, shifting dullness</td>
<td></td>
</tr>
</tbody>
</table>

**Legend:** O = absent; V = diminished; + = present, ← = direction of deviation
Resonance and hyperresonance: Pulmonary emphysema

- Loss of interstitial elasticity and interalveolar septa → air trapping, increased long volume.
- The lungs are in a continuous inspiratory position → increased AP diameter, barrel chest, horizontal costal margins that move sluggishly during inspiration. The diaphragm is pushed downward.
- Because of density, lungs are hyperresonant. Air pockets are poor transmitters of vibration → breath sounds, vocal fremitus whispered or spoken voice are impaired or absent.
Pulmonary emphysema
Resonance and hyperresonance: Pneumothorax

Symptoms:
• Sudden onset of chest pain referred to the shoulder or arm on the involved side. Dyspnea, cough are accompanied.

Forms:
• Closed PTX
• Open PTX: Complete collapse of the lung → mediastinum is drawn to the unaffected side. Fremitus, breath and voice sounds are absent. Severe dyspnoe and cyanosis are present
• Tension PTX: Wound of ingress serves as a wall, permitting air to be sucked up during inspiration but preventing loss during expiration → pressure in cavity builds up in excess of the atmosphere → extreme tracheal deviation and compression of the normal lung. Deep cyanosis, severe dyspnea, shock are present.
• In emergency: Aspiration of air away from the cavity
Pneumothorax X-ray: retraction of lung from pleura
Pneumothorax and hydropneumothorax
Tension pneumothorax and needling the chest for tension pneumothorax
Resonance and dyspnea: Pulmonary edema

- Paroxysmal onset with coughing, wheezing. Breathing is labored, with cyanosis and often with frothy sputum, occasionally bloody. Rales of various intensity can be heard.
- **Distinction:** from bronchial asthma.
- **Occurrence:** left heart failure, pulmonary disease, injury caused by noxious gases.
Resonance and dyspnea: Pulmonary fibrosis

- Chronic dyspnoe with normal thoracic resistance. Faint breath sounds, normal lung volume and density. Rales may be present.
- **Occurrence:** interstitial fibrosis, cystic fibrosis, allergic alveolitis, RA, Sjögren’s syndrome, scleroderma, Hamman-Rich disease, ornithosis, diffuse pulmonary carcinoma, SLE, PAN, sarcoid, tuberculosis, fungal infections, drugs.
Resonance and dyspnea: Acute tracheal or bronchial obstruction

- Complete obstruction of the trachea is incompatible with life. Partial obstruction causes violent prolonged inspiratory movements with extreme retraction of the intercostal spaces, suprasternal notch, supraclavicular fossae, and epigastrium.
- *Asthmatic wheeze:* low-pitched rhonchus may be heard over the chest during inspiration and expiration.
- *Ball-valve obstruction:* rhonchus occurs only during inspiration.
- *Bagpipe sign:* sound of expelling air continues after voluntary shortcut of expiration.
- *Palpable rhonchus:* occurs on the affected side during inspiration.
- *Pendular movement* of the trachea moving toward the affected side during inspiration, away with expiration.
- *Audible slap:* caused by foreign body during coughing or breathing.
- *Occurrence:* foreign body, neoplasm, diphtheric.
Resonance and rales: Bronchitis and bronchiectasis

**Bronchitis**
- Secretions in the bronchi produce rales, coarse, occasionally musical. Secretions high in the trachea produce rales heard throughout the entire thorax. X-ray shows no distinctive findings.

**Bronchiectasis**
- Copious sputum is produced by chronic coughing or postural drainage. Crackles and rhonchi can be heard over lower lobes. Routine chest X-rays lend little information unless bronchogram or CT is made.
Added lung sounds

- **Origin**
  - **Alveoli**
    - "Crepitation" heard only in inspiration
  - **Bronchi**
  - **Pleura or pericardium**
  - **Main airway obstruction**

- **Moist crakes**
  - **Fine**
  - **Medium**
  - **Coarse**

- **Dry**
  - **Wheezing**
  - **Ronchi**

**Rales**
**Rub (inflammation)**
**Stridor**
DRY RALES


**Wheezes and rhonchi (continuous sounds).** Are longer than crackles, do not necessarily persist throughout the respiratory cycle, are dry, coarse rales. Continuous sounds through bronchi narrowed or nearly closed. Occur in bronchial asthma, chronic bronchitis, cardiac asthma. A localized wheeze suggests partial obstruction in tumor or foreign body.

**Wheezes** are higher-pitched with hissing or shrill quality. **Rhonchi** are lower-pitched with snoring quality (but the distinction is not really important).
PNEUMOMEDIASTINUM

- Sudden onset of severe retrosternal pain
- Crepitus on palpation of neck and chest
- Crunching sound simultaneously with heartbeat
- X-ray is diagnostic
Added lung sounds

- **Origin**
  - Alveoli: "Crepitation" heard only in inspiration
  - Bronchi: Rales
  - Pleura or pericardium: Rub (inflammation)
  - Main airway obstruction: Stridor

- **Metrics**
  - **moist cracles**
    - fine
    - medium
    - coarse
  - dry
  - wheezing
  - ronchi
MOIST RALES = CRACLES

Are sounds from the movement of fluid or exudate in the airways or from the passage of air through constricted tubes. Can be altered by deep breath or coughing. Classification: moist and dry rales.

**Moist rales. Coarse rales or rhonchi or gurgling rales.** Occur in larger bronchi. Gurgles and usually occur in patients too weak to clear fluid from the larger airways.

**Fine or medium rales.** Are caused by relatively thin fluid moving in the bronchi or bronchioles. Sound like clicks or small bubbles. Occur in bronchitis, pneumonic consolidation, infarction, lung abscesses, bronchiectasis. Chest hair can also produce the same sound!
Added lung sounds

Origin
- Alveoli
  - "Crepitation" heard only in inspiration
- Bronchi
- Rales
- Pleura or pericardium
- Rub (inflammation)
- Main airway obstruction
- Stridor
  - Moist cracles
    - Fine
    - Medium
    - Coarse
  - Dry
    - Wheezing
    - Ronchi
Stridor

- Loud wheeze, predominantly inspiratory, indicates partial obstruction of large airways.
## Signs of different chest disorders

<table>
<thead>
<tr>
<th>Condition</th>
<th>Trachea</th>
<th>Percussion</th>
<th>Breath sounds</th>
<th>Tactile fremitus</th>
<th>Adventitious sounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>midline</td>
<td>resonant</td>
<td>vesicular</td>
<td>normal</td>
<td>none transient crackles</td>
</tr>
<tr>
<td>Chronic bronchitis</td>
<td>midline</td>
<td>resonant</td>
<td>vesicular</td>
<td>normal</td>
<td>none coarse crackles wheezes</td>
</tr>
<tr>
<td>Left-sided heart failure</td>
<td>midline</td>
<td>resonant</td>
<td>normal</td>
<td>normal</td>
<td>crackles (late inspir.)</td>
</tr>
<tr>
<td>Lobar pneumonia</td>
<td>midline</td>
<td>dull over</td>
<td>bronchial</td>
<td>increased over involved area</td>
<td>crackles (late inspir.)</td>
</tr>
<tr>
<td>Condition</td>
<td>Trachea</td>
<td>Percussion</td>
<td>Breath sounds</td>
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<td>--------------------</td>
</tr>
<tr>
<td>Atelectasia</td>
<td>Shifted toward involved side</td>
<td>dull over airless area</td>
<td>absent</td>
<td>absent</td>
<td>none</td>
</tr>
<tr>
<td>Pleural effusion</td>
<td>shifted toward opposite side</td>
<td>dull or flat over fluid</td>
<td>decreased or absent</td>
<td>decreased or absent</td>
<td>none</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>shifted toward opposite side</td>
<td>hyperresonant or tympanic</td>
<td>decreased or absent</td>
<td>decreased or absent</td>
<td>none</td>
</tr>
<tr>
<td>Emphysema</td>
<td>Midline</td>
<td>hyperresonant</td>
<td>decreased or absent</td>
<td>decreased</td>
<td>wheezes crackles</td>
</tr>
<tr>
<td>Bronchial asthma</td>
<td>Midline</td>
<td>normal or hyperresonant</td>
<td>obscured by wheezes</td>
<td>decreased</td>
<td>wheezes crackles</td>
</tr>
</tbody>
</table>
### Diagnostic procedures in respiratory disease 1

#### Measurement of ventilatory function

<table>
<thead>
<tr>
<th></th>
<th>Restriction due to increased lung elastic recoil (pulmonary fibrosis)</th>
<th>Restriction due to chest wall abnormality (moderate obesity)</th>
<th>Restriction due to respiratory muscle weakness (myasthenia gravis)</th>
<th>Obstruction due to airway narrowing (acute asthma)</th>
<th>Obstruction due to decreased elastic recoil (severe emphysema)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TLC</strong></td>
<td>60%</td>
<td>95%</td>
<td>75%</td>
<td>100%</td>
<td>130%</td>
</tr>
<tr>
<td><strong>FRC</strong></td>
<td>60%</td>
<td>65%</td>
<td>100%</td>
<td>104%</td>
<td>220%</td>
</tr>
<tr>
<td><strong>RV</strong></td>
<td>60%</td>
<td>100%</td>
<td>120%</td>
<td>120%</td>
<td>310%</td>
</tr>
<tr>
<td><strong>FVC</strong></td>
<td>60%</td>
<td>92%</td>
<td>60%</td>
<td>90%</td>
<td>60%</td>
</tr>
<tr>
<td><strong>FEV₁</strong></td>
<td>75%</td>
<td>92%</td>
<td>60%</td>
<td>35% pre-b.d.</td>
<td>35% pre-b.d.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>75% post-b.d.</td>
<td>38% post-b.d.</td>
</tr>
<tr>
<td><strong>R̅aw</strong></td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>2.5</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>DLCO</strong></td>
<td>60%</td>
<td>95%</td>
<td>80%</td>
<td>120%</td>
<td>40%</td>
</tr>
</tbody>
</table>

Commonly seen abnormalities of pulmonary function values are expressed as percent of normal, except for $R_{aw}$, which is expressed as cmH₂O/L/s (normal).

The figures at the bottom of each column show typical flow-volume loops in each condition, including the flow-volume relationship during tidal breathing. b.d., bronchodilator; DLCO, diffusion capacity of lung for carbon monoxide; FEV₁, forced expiratory volume in one second; FRC, functional residual capacity; FVC, forced vital capacity; $R_{aw}$, airways resistance; RV, residual volume; TLC, total lung capacity.
Diagnostic procedures in respiratory disease 2
Measurement of gas exchange

- Diffusing capacity
- Arterial blood gases
- Pulse oxymetry
Diagnostic procedures in respiratory disease 3

Imaging studies

- Routine chest X-ray
- Computerized tomography (incl. helical and multidetector CT scanning)
- Magnetic resonance imaging (MRI)
- Nuclear medicine techniques
- Positron emission tomography (PET)
- Pulmonary angiography
- Ultrasound
- Virtual bronchoscopy
Diagnostic procedures in respiratory disease

Medical techniques for obtaining biologic specimens

- Collection of sputum (staining, culture)
- Percutaneous needle aspiration
- Thoracocentesis
- Bronchoscopy
- Transbronchial and endobronchial needle aspiration
- Pleural biopsy
- Thoracoscopy and thoracotomy
- Mediastinoscopy and mediastinotomy