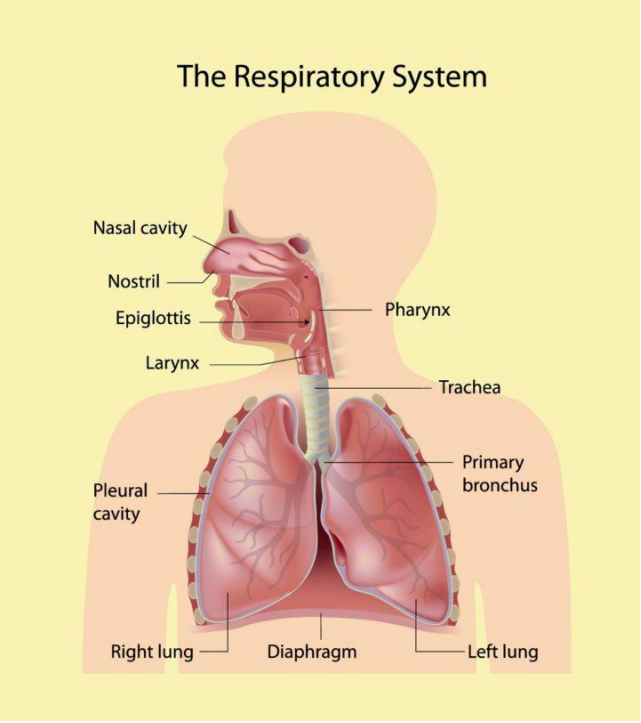
Chapter 20

Respiratory inflammation and infection

1

Respiratory failure:

- Acute or chronic
- **hypoxemic** (pulmonary system fails to oxygenate the blood)
- **hypercapnic** (fails to sufficiently eliminate carbon dioxide)
- Caused by:
    - Smoking
    - occupational or environmental exposures (coal, silica, and asbestos, radon gas)
    - indoor chemical agents (from synthetic fibers and building materials: formaldehyde, diisocyanates, latex particles, that circulate within the air of poorly ventilated buildings)



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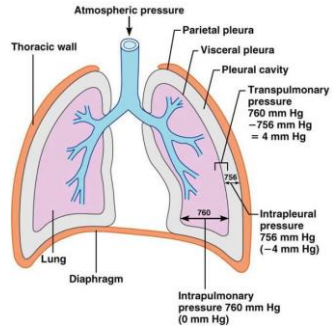
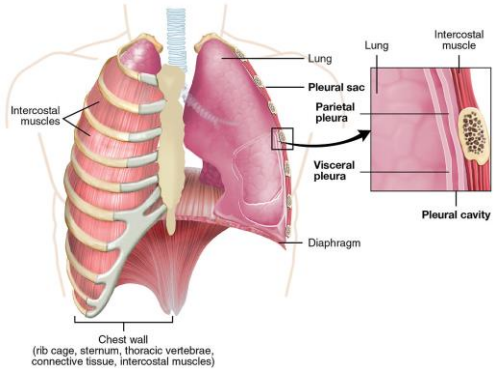
respiratory **pressures** that govern ventilation:

- Negative intrapleural pressure holds the lungs against the chest wall.
- Between the parietal and visceral pleura we have a tiny space (intrapleural space). The pressure in this space is negative, compared with the atmospheric pressure.





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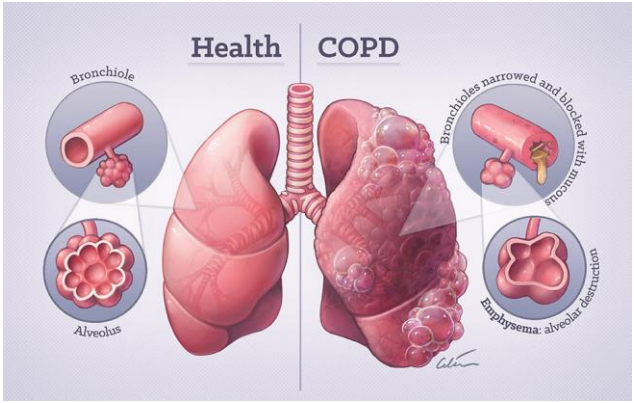
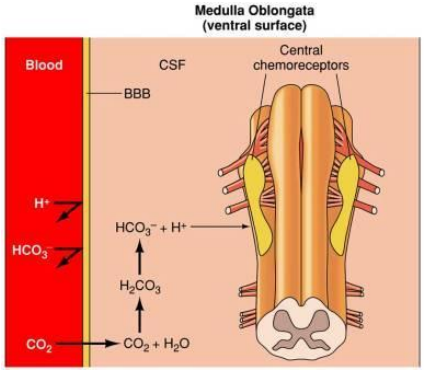
- Mr. Dewer has a longstanding COPD. He is receiving oxygen at 1L/min per nasal canula.
- Why the O2 administration is maintained in a low setting?



4

Control and Stimulus of Breathing

- Various receptors control the process, rate, and depth of respirations during inspiration and expiration.



Central chemoreceptors (in the medulla)

- → sense changes in **carbon dioxide** and **blood pH** and cause alterations in the rate and depth of respirations.
- ↑CO2 (hypercapnia) or ↓pH (acidosis) stimulates the central chemoreceptors →↑ RR.
- → sense the **hydrogen (H+)** concentration of the cerebrospinal fluid (CSF). ↑ or ↓ of pH in the arterial blood is reflected in a chemical change in the CSF.
- When CO2 is retained, carbonic acid (H2CO3) levels in the blood increase.
  - This increases the PaCO2 level and lowers blood pH.
- In response to these changes, the respiratory center at the medulla stimulates respirations.

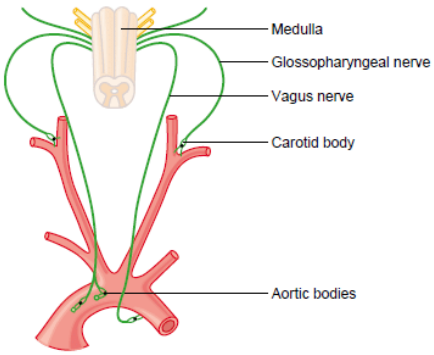
5

Control and Stimulus of Breathing

Peripheral chemoreceptors

- called carotid bodies (in the aortic arch and bifurcation of the carotid artery)
- respond primarily to ↓arterial oxygen → stimulate respirations (**hypoxic drive**).

- *when central chemoreceptors are exposed to high levels of CO2 for extended periods, they become less responsive.* (as in diseases such as [COPD]).
  - *The blunted response to CO2 allows the peripheral chemoreceptors of low O2 to take over as the stimulus of respirations.*
  - *This response correlates with a PaO2 level of about 60 mm Hg, the point at which oxygen fully dissociates from hemoglobin.*



➢ We also have:
- ➢ **Baroreceptors** (in the aortic arch and carotid artery). When systolic blood pressure drops they stimulate the SNS to increase HR and RR.
- ➢ **Proprioceptors** (in the muscles of movable joints). When stimulated by exercise, increase RR and depth.
- ➢ **Hering–Breuer reflexes**: stretch reflexes (in the bronchi and bronchioles). When lungs inflate, neuronal impulses are sent up the vagus nerve to the medulla. The result is an inhibition of rate, rhythm, and duration of inspiration, which prevents the overdistention of the lungs.

6

- Mr. Dewer has a longstanding COPD. He is receiving oxygen at 1L/min per nasal canula.
- Why the O2 administration is maintained in a low setting?

→*hypoxia is the main stimulus for respirations in people with longstanding COPD*

→Administering high doses of oxygen can depress the patient's independent drive to breathe and cause respiratory arrest.

→Careful, slow upward titration of oxygen is necessary when the patient requires oxygen therapy.

→Any agents that depress respiratory drive, such as tranquilizers, sedatives, and opiates, should be used with caution.

7

COPD (chronic obstructive pulmonary disease)

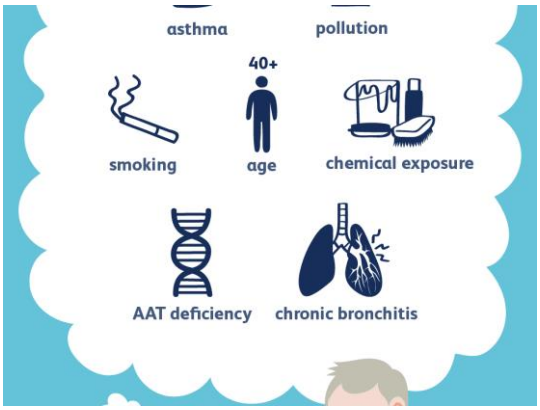
COPD is combination of chronic bronchitis, emphysema, and hyperreactive airway disease.

Epidemiology

- 3rd leading cause of death in the US, and a leading cause of disability (most > age 45)

Etiology

- Smoking (major cause)
- occupational and environmental exposures to chemicals, dusts, and secondhand smoke are also causes
- combination of genetic susceptibility (alpha 1 anti-trypsin (AAT) deficiency - less than 1% of all cases) and environmental factors
- IV drug abuse has been associated with emphysema (has components such as talc)
- *Pneumocystis jiroveci* (infection in individuals with AIDS).
- Connective tissue diseases (Marfan syndrome; Ehlers–Danlos syndrome)



8

COPD (chronic obstructive pulmonary disease)

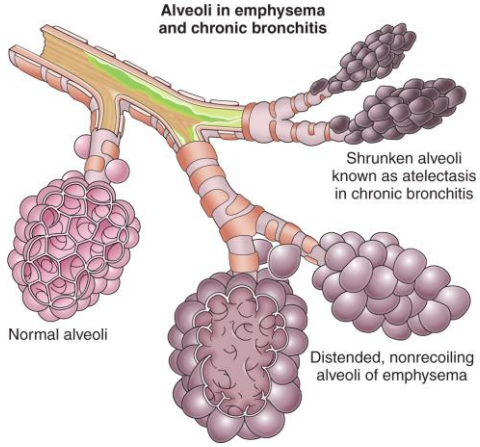
Pathophysiology

❖ Characteristics:

- **Chronic bronchitis** → hypersecretion of mucus in the large and small airways → obstruction to inspiratory airflow →hypoxia → cyanosis.
- **Emphysema** → overdistention of alveoli with trapped air → obstruction to expiratory airflow. Loss of elastic recoil of the alveoli → high residual volume of carbon dioxide.
- **Airways hyperreactive** to irritants → episodes of bronchoconstriction.

❖ Pathological changes:

- Narrowing
- Excessive mucus and fibrosis in the bronchioles,
- Loss of alveolar elastic recoil
- Smooth muscle hypertrophy.
- **Inflammatory changes (**chronic bronchitis) → permanent remodeling of the pulmonary structure (inflammatory reactions damaging lung structures, thickening the walls, constricting the lumens)



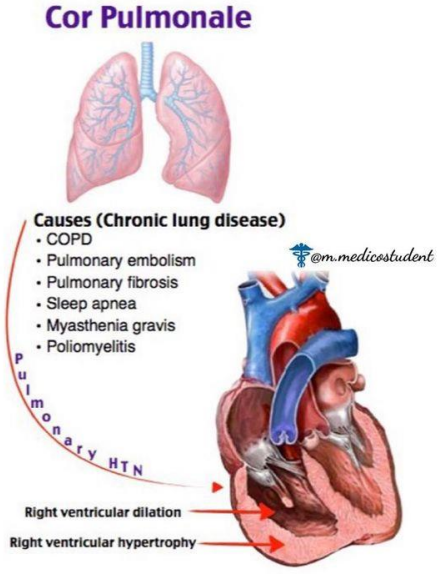
9

COPD (chronic obstructive pulmonary disease)

Pathophysiology (cont.)

Severe COPD:

- **poor ventilation** → **hypoxia** → hypoxia stimulates pulmonary arterial vasoconstriction
  - **Pulmonary arterial vasoconstriction** (called **pulmonary hypertension**) → causes increased resistance in the main pulmonary artery → increased resistance against the right ventricle.
  - **Chronic pulmonary hypertension** causes right ventricular hypertrophy and eventual **right ventricular failure**. = **cor pulmonale**.
    - **Signs and symptoms**: jugular venous distension, ascites, hepatomegaly, splenomegaly, ankle or sacral edema.



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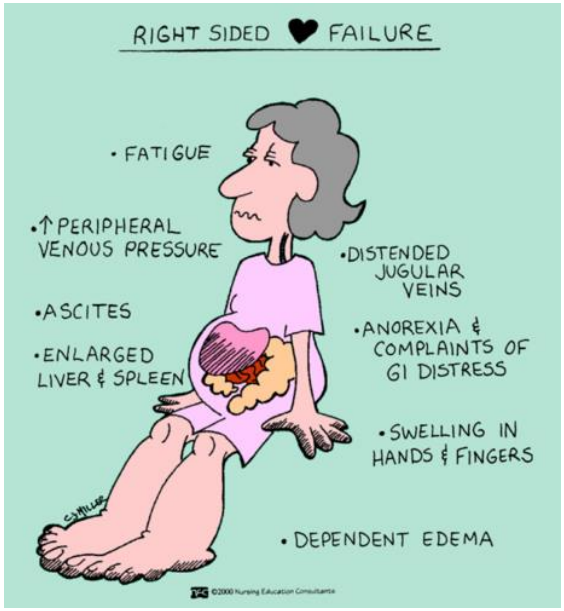
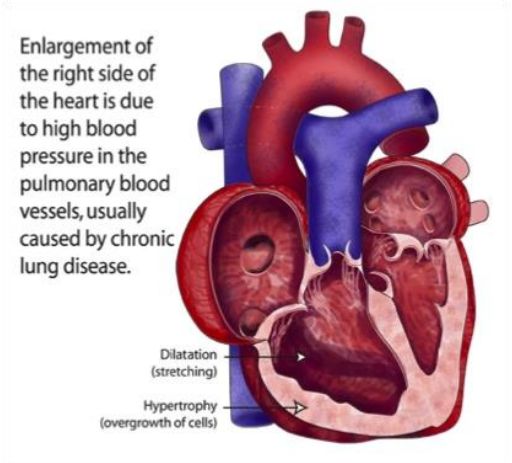
COR PULMONALE



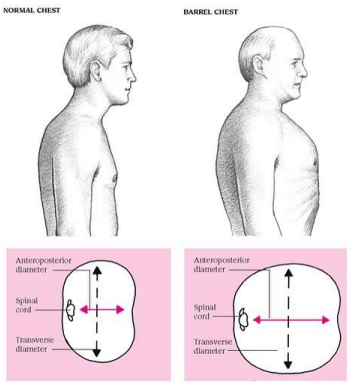


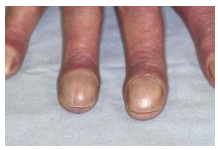
11

COPD (chronic obstructive pulmonary disease)

Signs and Symptoms. (S/S of chronic bronchitis, emphysema, and asthma).

- Dyspnea (initially occurring with heavy exertion)
- Cough or wheezing (cough may be productive, and sputum should be expectorated for culture).
- Hypoxia → cyanosis
  - Hypoxia stimulates pulmonary arterial vasoconstriction → right ventricular failure occurs.
- Barrel-shaped chest
- Distended jugular veins
- Ascites,
- Ankle edema
- Vital signs: RR , rhythm, and depth.= prolonged exhalation and purse the lips when exhaling.
- Posterior lung tactile fremitus.
- The posterior lung resonance. In severe emphysema, hyperresonance may be percussed because of the extra air retained in the lungs.
- Wheezing
- Diminished breath sounds
- Auscultate the heart and note any abnormal sounds.





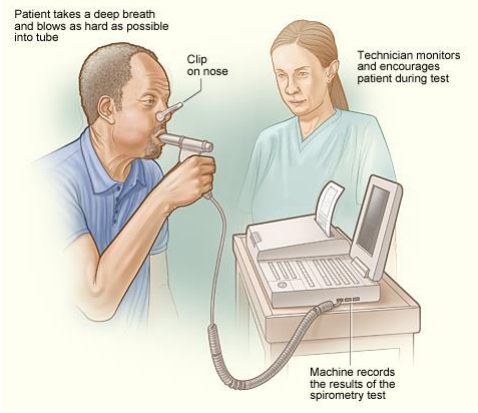
Observe the patient for signs of respiratory distress: use of intercostal muscles or accessory muscles with breathing, and clubbing of the fingers

12

COPD (chronic obstructive pulmonary disease)

Diagnosis

- The COPD Assessment Test (CAT) = 8 questions that ask about breathlessness, cough, chest tightness, sputum, and activity level. Each item is scored on a scale of 0 to 5, with a higher total score indicating more severe disease.
- PFTs (also called spirometry) are a key part of the diagnosis of COPD. Measure FVC (total volume of air that can be exhaled with maximum effort) and FEV1 (volume of air expelled during the first second of exhalation of air from the lungs).
- Complete Blood Count (CBC)
- Blood chemistry panel
- Chest x-ray
- Electrocardiogram (ECG),
- ABGs



13

COPD (chronic obstructive pulmonary disease)

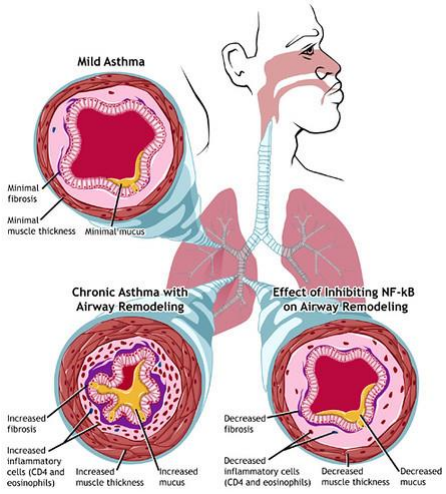
Treatment

- Bronchodilators (SABAs and LABAs)
- Anticholinergic (counteract bronchoconstriction) = **long-acting antimuscarinic agents**, or LAMAs
- Phosphodiesterase inhibitors, such as theophylline - when the patient does not respond adequately to bronchodilators.
- Oral corticosteroids - when the patient has an acute exacerbation and does not respond adequately to bronchodilators. (The patient needs to use oral corticosteroids in low doses for a short time and be weaned off them slowly)
- Leukotriene antagonists (asthma and COPD) to counteract bronchoconstriction and inflammation in the bronchioles.
- Nonpharmacological interventions (smoke cessation, pulmonary rehabilitation, O2)
- Continuous oxygen therapy (PO_2 ≥ 55 mm Hg or O2 saturation ≥ 88%, or evidence of pulmonary hypertension, cor pulmonale, cognitive impairment caused by hypoxia, or polycythemia and a PO_2 of 56 to 59 mm Hg.
- Oxygen should be used in the lowest doses that can enhance the patient's oxygenation.
- Oxygen therapy requires slow upward titration to the level that assists the patient's oxygenation while still maintaining the patient's independent respiratory drive.

14

Asthma

- chronic inflammatory disease with acute episodes of bronchospasm (also called hyperreactive airway disease)
- With each acute attack, deleterious bronchial **remodeling** and inflammatory changes develop in the bronchioles, so the aim of treatment is to prevent acute asthma attacks.
- **Prevention** of asthma attacks is critical to avert bronchial airway alterations.
- **Allergy**: common stimulus of asthma.
  - Allergens trigger the immune system → causing bronchial constriction, inflammation, and an increase in the size and number of goblet cells that secrete mucus.
  - There is bronchoconstriction, bronchial edema, viscous mucus, and thickening of the bronchial basement membrane.

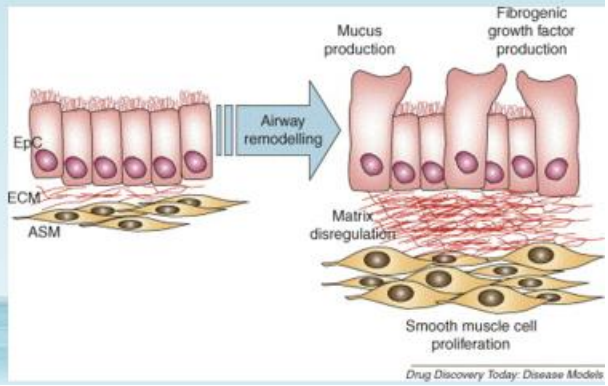


15

why the prevention of asthma exacerbations is important? Because with each exacerbation bronchial remodeling occurs = structural alterations

- Asthma is a chronic inflammatory disease that causes episodes of spastic reactivity in the bronchioles.
- With each bout of acute bronchospasm in asthma, deleterious bronchial remodeling occurs.
- Prevention of asthma attacks is critical to avert bronchial airway alterations.
  - proliferation of respiratory epithelium
  - hypertrophy of respiratory smooth muscle

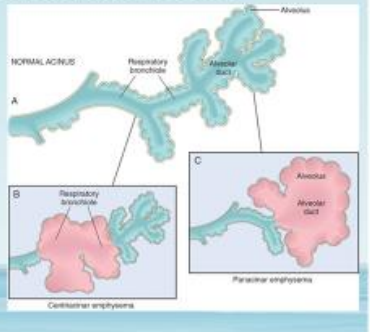
- Not because asthma is difficult to manage
  - Depends on frequency and severity of asthma symptoms, FEV1, and FEV1/FVC measurements
- Not because GERD can trigger asthma
  - Gerd can trigger symptoms like asthma because of the acid in the trachea
- a portable O2 sensor can be helpful to monitor oxygen saturation(this does not answer the question)

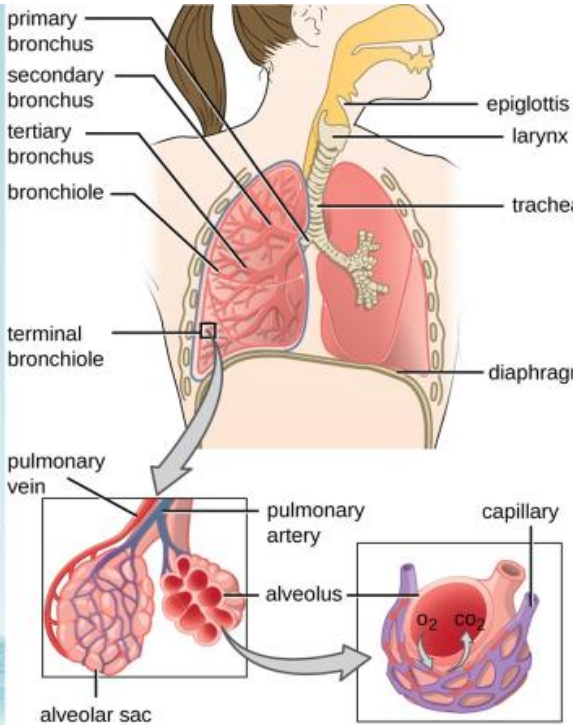


16

irreversible enlargement of the air spaces beyond the terminal bronchioles, (the alveoli), resulting in **destruction of the alveolar walls** and obstruction of airflow is a characteristic of emphysema ----------→

- chronic obstructive pulmonary (COPD) disease is a combination of Emphysema, asthma, chronic bronchitis (i.e.,chronic inflammation of the bronchial tubes)





17

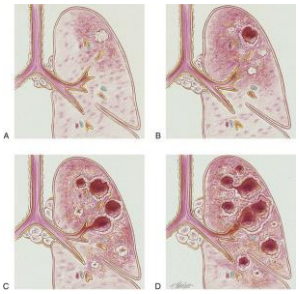
Tuberculosis (TB)

- infection caused by the *Mycobacterium tuberculosis*
- Most commonly occurring in the lungs
- 2 forms:
  - TB disease: symptoms and clinical evidence of active disease
  - Latent TB infection (LTBI): disease is dormant (no clinical symptoms and is noninfectious)
  - Both forms require treatment (LTBI can convert to active TB)
- spread by the inhalation of airborne droplets containing *M. tuberculosis* bacteria.

18

Pathophysiology

- *M. tuberculosis* inhaled → droplets pass down the airway → settle in the bronchial tree.
  - aerobic and prefers areas of lung tissue with high O_2 levels
- Tissue inflammation occurs as the bacteria multiply and pulmonary macrophages and white blood cells (WBCs) migrate to the infected area.
- WBCs cannot kill the organism
- cell-mediated immune response occurs that eventually walls off the infection.
  - The lesion, called a **tubercle**, is a granulomatous accumulation of WBCs, fibrotic tissue.
- Scar tissue eventually grows around the tubercle, and the bacteria become inactive.
- The bacteria continue to multiply, and macrophages and T cells degrade the bacteria.
- The macrophages and T cells continue to be stimulated, secrete enzymes, and kill bacteria.
- The enzymes, however, also damage lung tissue.
- Necrotic lung tissue takes on a cheese-like appearance; histologically, it is called caseous necrosis.
- In this tissue, the bacteria remain dormant, though any impairment of the patient's immune response allows reactivation of TB infection. The bacteria reinfect the bronchial tree, allowing the patient to spread the disease.



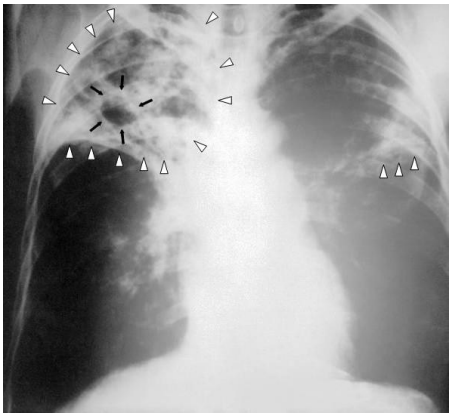
19

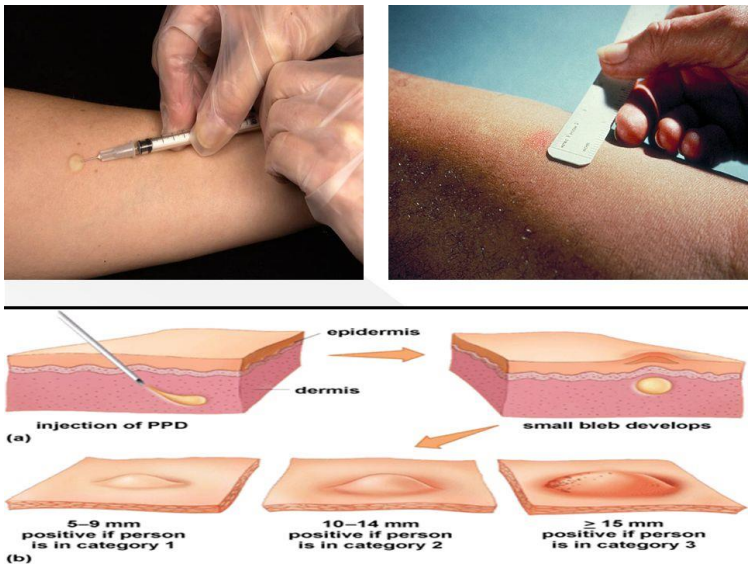
Diagnosis

- The **Mantoux tuberculin skin test** (**PPD test)** is a screening test for TB.
- → indicate only if an individual has had prior exposure and sensitization to the organism *M. tuberculosis.*
- It does not differentiate LTBI from active TB disease.
- small amount of purified protein derivative (PPD), which is an extract of the tubercle bacteria, is injected intradermally into the forearm.
- After 48 hours, the injection site should be checked for a reaction of induration, which appears as elevated and hardened.
- If there is no induration at the site, the test is negative and the individual is considered uninfected.
- An induration of 5 to 15 mm may be positive, depending on the person's risk factors and susceptibility to TB.
- A reaction greater than 15 mm of induration is interpreted as positive in all persons.

20

If a **PPD** is **positive and a** follow-up **chest x-ray shows active tuberculosis,** this patient's diagnosis is Active TB





21

Treatment

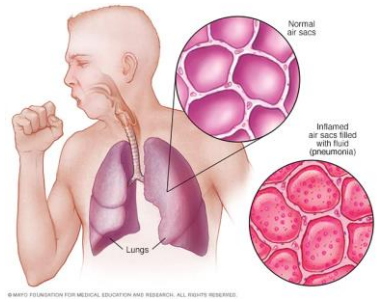
- Antimicrobial medications (isoniazid, rifampicin, pyrazinamide, ethambutol, and streptomycin)

- TB bacteria mutate rapidly and easily acquire resistance to any one drug; therefore, usually a **combination of four different drugs** is used.
- Multidrug therapy is required for a **long time**, usually 6 to 12 months, and may need to continue longer in patients with an HIV infection or those with drug-resistant strains of TB.

- Because the bacteria travel through the air, patients are placed in respiratory isolation until they are no longer considered contagious.
- Adequate hydration and nutrition are necessary to aid in recovery from the disease.
- TB is considered chronic in nature, as there is a potential for reactivation of active disease if a patient becomes immunosuppressed.

22

Pneumonia



- Infection and inflammation process in the lobes of the lungs
- Causes:
  - bacteria, viruses, fungi, parasites, mycoplasma, or chemicals.
- Signs and Symptoms:
  - Exudates fill the alveolar air spaces, creating consolidation and impaired air exchange, resulting in hypoxia.
  - Difficulty breathing.
  - Fever, cough, chills, malaise, myalgias.
  - Pleuritic chest pain.
  - Sputum production.
  - Fever
  - Crackles

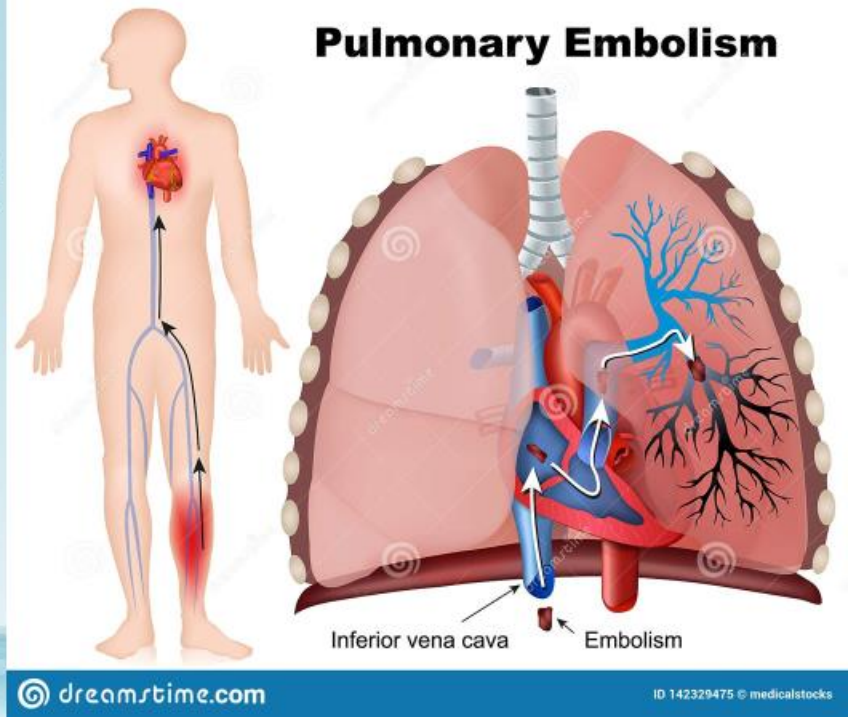
A pneumonia that occurs **48 hours or more after admission to the hospital** is considered

hospital-acquired pneumonia

23

pathophysiological changes involved in a **pulmonary embolism.**

1. 1st - Inflammation occurs and a thrombus forms in the vein.
2. 2nd - The thrombus becomes an embolus and travels into the inferior vena cava.
3. 3rd - The thrombus travels into the right side of the heart.
4. 4th - The thrombus then enters the pulmonary artery.



24

pulmonary embolism

Signs and Symptoms:

- Anxiety; Tachycardia; Dyspnea; Cough; chest pain
- PE is a leading cause of death because the clinical presentation is often vague and occurs without warning.

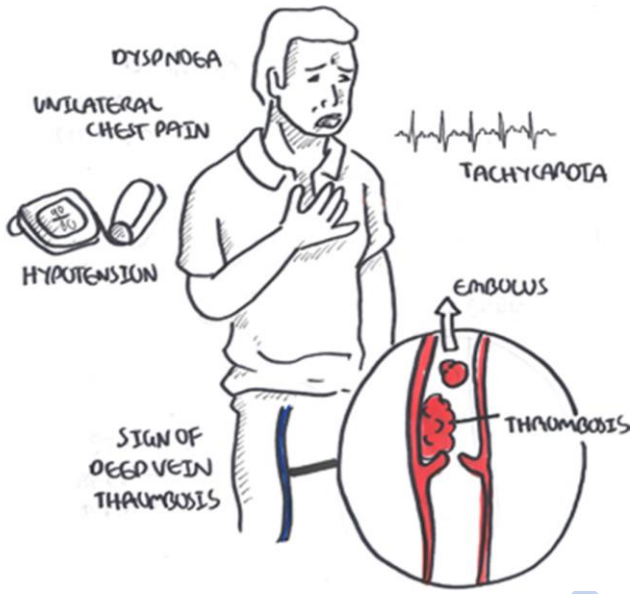
Diagnostic tests:

- D-dimer test (measures the amount of fibrin degradation products in the blood)
- CT pulmonary angiography.. If the D-dimer test is normal, there is little chance that the patient is enduring a PE.

Treatment:

- Direct oral anticoagulants (DOACs) (e.g., rivaroxaban, apixaban). (continued for at least 3 months to prevent early recurrences)
- DOACs are preferred over the vitamin K antagonist warfarin because they are associated with a lower risk of bleeding than warfarin and do not require frequent laboratory testing.
- Thrombolytic agents (e.g., tissue plasminogen activator [tPA]) are used if PE is associated with hemodynamic instability.
- Surgical implantation of an inferior vena cava filter may be necessary with multiple PE formation.

25

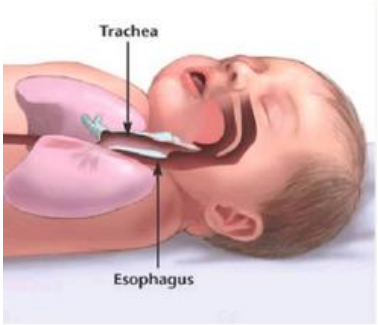


26

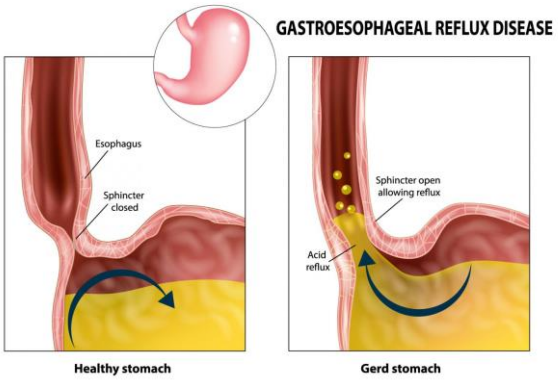
Aspiration

Common in babies with **gastroesophageal reflux**

- spits up after feedings
- irritable for about 1 hour after eating (hungry again)
- **risk for pneumonia**



Picture 1



27