Study Guide for Exam 4

The Respiratory System

Mechanics of breathing

- Consists of two phases:
    1. Inspiration/inhalation: air flows into the lungs because the air pressure inside the lungs is less than the air pressure in the atmosphere
        - For inhalation to occur, the lungs must expand, which increases lung volume and decreases the pressure in the lungs to below atmospheric pressure
        - The diaphragm and internal intercostals must contract first. Contraction of the diaphragm causes it to flatten, increasing the diameter of the thoracic cavity. When external intercostals contract, they elevate the ribs, increasing the diameter of the thoracic cavity
    2. Expiration/exhalation: gases exit the lungs when the air pressure inside the lungs is greater than the air pressure in the atmosphere
        - During quiet breathing, exhalation is passive, resulting from elastic recoil of the of the chest wall and lungs
        - In forceful breathing, the abdominals and internal intercostals contract, increasing the pressure in the abdominal region and thorax, forcing the diaphragm superiorly
- Boyle's law: pressure and volume are inversely proportional; if the volume of a container is increased, the pressure will decrease

Pressure relationships in the thoracic cavity

- Pressure in the thoracic cavity can be changed using the diaphragm
- Respiratory pressure is always described relative to atmospheric pressure
    - Atmospheric pressure (P_{atm}): pressure exerted by the air surrounding the body (760 mmHg at sea level)
    - Negative respiratory pressure is less than P_{atm}
    - Positive respiratory pressure is greater than P_{atm}
- Intrapleural (intrathoracic) pressure: the pressure between the two pleural layers in the pleural cavity, is always lower than atmospheric pressure
- Alveolar (intrapulmonic) pressure: the pressure inside the lungs; must be lower than 760 mmHg for inhalation to occur

Pulmonary ventilation: (breathing) the inflow and outflow of air and involves the exchange of air between the atmosphere and the alveoli of the lungs

- The flow is due to alternating pressure differences created by relaxation and contraction of respiratory muscles
- Physical factors influencing pulmonary ventilation:
    - Alveolar surface tension: surface tension must be overcome to expand the lungs during each inhalation; also provides 2/3 of the force for elastic recoil

    - Lung compliance: how much effort is required to stretch the lungs and chest wall; high compliance means that they will expand easily; lungs normally have high compliance
    - Airway resistance: walls of the airways provide some resistance; resistance increases during exhalation due to smaller bronchioles
        - Friction is the major nonelastic source of resistance
        - As airway resistance rises, breathing becomes more strenuous
        - Severely constricted/obstructed bronchioles can prevent life-sustaining ventilation or can occur during acute asthma attacks
- Ventilation is breathing while respiration is the exchange of gases
- Size of the thoracic cavity (determined by respiratory muscles) and change in pressures in the lungs.

Dead space and alveolar ventilation

- Anatomical (respiratory) dead space: the conducting airways with air that does not undergo respiratory exchange; usually about 150 mL of the 500 mL tidal volume (the volume of one breath)
- Alveolar ventilation rate: the amount of air that actually reaches the respiratory zone
    - Measures the flow of fresh gases into and out of the alveoli during a particular time
    - Slow, deep breathing increase AVR
    - Rapid, shallow breathing decreases AVR

AVR	=	**Frequency**	**X**	**(TV – dead space)**
(ml/min) **5250 ml/min**		**(Breaths/min)** **15/min**		**(ml/breath)** **350 ml**

Gas exchange between blood, lungs and tissues. Partial pressures of O2 and CO2 in atmospheric air, alveolus, pulmonary circulation, systemic circulation and cells.

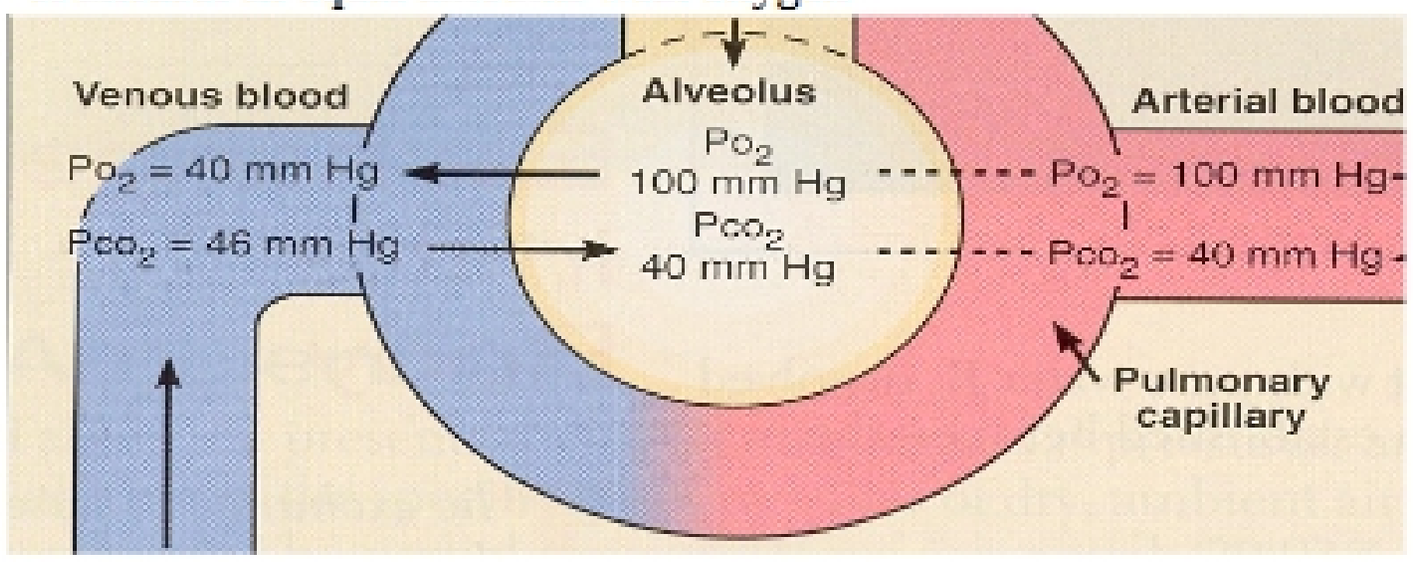
- The exchange of oxygen and carbon dioxide between alveolar air and pulmonary blood occurs via passive diffusion
- Dalton's law: each gas in a mixture of gases exerts its own pressure as if no other gases were present
    - Partial pressure (P_X): % concentration x total pressure
    - Total pressure exerted by a mixture of gases is the sum of the pressures exerted independently by each gas in the mixture
    - 79% of atmospheric pressure is nitrogen
    - Partial pressures determine the movement of oxygen and carbon dioxide between the atmosphere and lungs, between the lungs and blood, and between the blood and body cells
    - The greater the difference in partial pressure, the faster the rate of diffusion

- Compared with inhaled (atmospheric) air, alveolar air has less O_2 and more CO_2 because (1) gas exchange in the alveoli increases the CO_2 content and decreases the O_2 content of alveolar air, (2) when air is inhaled it becomes humidified as it passes along the moist mucosal linings so O_2 decreases
- Exhaled air continues more O_2 than alveolar air because some of the air was trapped in the anatomical dead space and did not participate in gas exchange

- Henry's law: the quantity of a gas that will dissolve in a liquid is proportional to the partial pressure of the gas and its solubility
  - More gas molecules are soluble at a higher pressure
- In pulmonary circulation (diffusion of oxygen from alveolar air into pulmonary capillaries and carbon dioxide in the opposite direction), deoxygenated blood becomes oxygenated, meaning that oxygen is picked up along the way
- In systemic circulation (the exchange of oxygen between systemic capillaries and tissue cells), oxygenated blood becomes deoxygenated, meaning that oxygen is more prevalent in the tissue cells

External respiration: partial pressure gradients

- Pulmonary gas exchange
- The diffusion of O_2 from air in the alveoli of the lungs to blood in pulmonary capillaries and the diffusion of CO_2 in the opposite direction
- External respiration in the lungs converts deoxygenated blood coming from the right side of the heart into oxygenated blood that returns to the left side of the heart
- Although carbon dioxide has a lower partial pressure gradient:
  - It is 20 times more soluble in membranes than oxygen
  - It diffuses in equal amounts with oxygen



Transport of respiratory gases by blood (Oxy-Hb dissociation curve)

- 1.5% of inhaled oxygen is dissolved in blood plasma
- 98.5% of blood oxygen is bound to hemoglobin in red blood cells
- Each 100mL of oxygenated blood contains 20mL of gaseous oxygen (98%)
- As arterial blood flows through capillaries, 5mL of oxygen are released to tissues
- Saturated Hb is when all four hemes of the hemoglobin molecule contain an atom of iron, each capable of binding to a molecule of oxygen; oxygen and hemoglobin bind in a reversible reaction that forms oxyhemoglobin

$$Hb + O_2 \leftrightarrow Hb\text{-}O_2$$