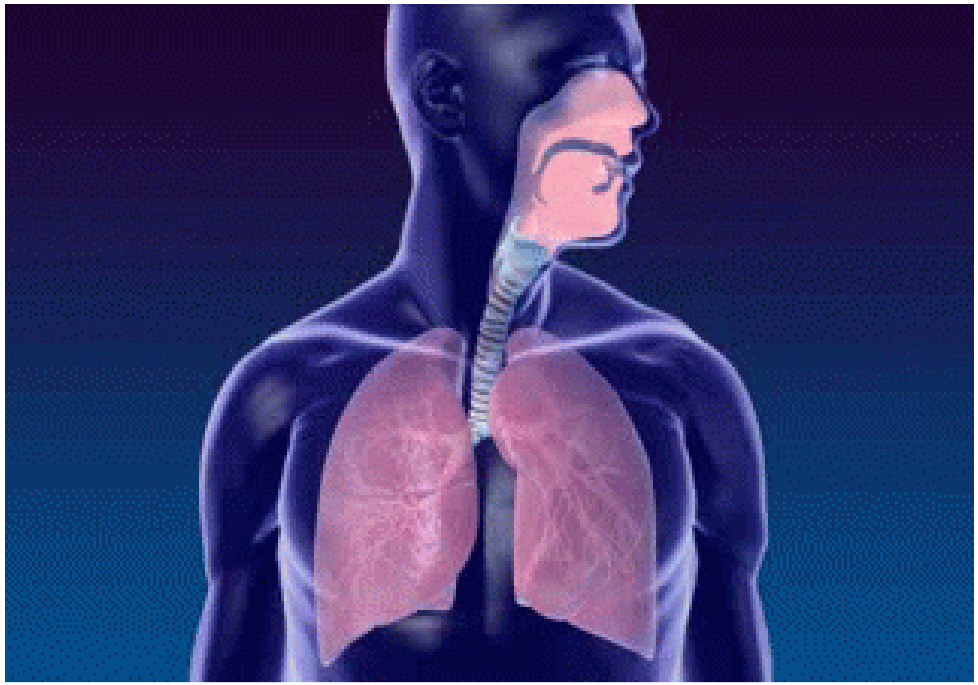
RESPIRATORY SYSTEM



Respiratory System Functions & Structures

- **Functions:**
  - **Exchange of gases between the atmosphere and the blood-** inhale O_2 and exhale CO_2
  - **Homeostatic regulation of body pH-** the amounts of CO_2 in the blood affect the pH
  - **Protection from inhaled pathogens and irritating substances-** preventive mechanisms against pathogens that could cause harm
  - **Vocalization**- voice production is possible when one exhales

- Flow takes place from regions of higher pressure to regions of lower pressure
- A muscular pump creates pressure gradients
- Resistance to air flow is influenced primarily by the diameter of the tubes through which air is flowing.

Cellular is the intracellular reaction of oxygen with organic molecules to produce CO2 , water and energy (ATP).
External is the movement of gases between environment and body's cells.

Processes of external respiration

- The exchange between the atmosphere and the lungs (ventilation/breathing)
- ***Inspiration (inhalation)***

Movement of air into the lungs

- ***Expiration (exhalation)***

Movement of air out of the lungs

- The exchange of O_2 and CO_2 between lungs and the blood
- The exchange of O_2 and CO_2 by the blood
- The exhange of gases between blood and the cells

Structures involved in ventilation and gas exchange

Conducting system (airways)- lead from external environment to the exhange surface of the lungs

Alveoli (alveolus) form exchange surface
O_2 from inhaled air to the blood, CO_2 from the blood to the air

Bones and muscle of thorax and abdomen- (muscular pump) increase or decrease pressure to help ventilation

The Pleural Sac

Each lung is surrounded by a double-walled pleural sac which cover outer surface of the lungs.
Total volume is 25-30 ml of a 70 kg man.

It creates a moist, slippery surface.

It protects the lungs, holds them tight, reduces friction

As airways get narrower, their number increase geometrically. CSA increases with each division. It is lowest in the upper part and greatest in the broncioles. Velocity of air flow is inversely proportional to CS. It is greatest in the upper part and lowest in the broncioles.

Conditioning

Airways plays an important role in conditioning air before it reaches the alveoli.

- Warming air to body temperature (Alveoli are not damaged by cold)
- Adding water vapor until the air reaches 100% humidity

(Moist exchange epithelium does not dry out)

- Filtering out foreign material (Pathogens do not reach the alveoli)

•Airways are lined with ciliated epithelium whose cilia are bathed in a watery saline layer.
•A sticky layer of mucus floats over the cilia to trap most inhaled particles.
•Goblet cells secrete mucus.
•Cilia move mucus upward toward pharynx (**mucociliary escalator**)
•Mucus contains Ig's that can disable pathogens.
Once it reaches the pharynx, it can be spit out (expectorated) or swallowed.

CTFR channel whose malfunction causes cystic fibrosis.

In cystic fibrosis, movement of fluid decreases. Cilia become trapped in thick and sticky mucus. Mucus cannot be cleared and bacteria colonize the airways, resulting in lung infections.

Alveoli are the site for exchange.

There is an extensive network of capillaries in contact with alveoli which is essential for rapid exhange of gases.

95% of cells are type 1 and used for gas exchange. They are very thin so gases can diffuse rapidly.
Smaller but thicker type 2 cells secrete **surfactant** to aid lungs to expand.

PULMONARY CIRCULATION

- High flow

It receives the entire CO

- Low pressure

(25/8 mmHg)

RV does not have to pump forcefully because resistance of pulmonary circulation is low (short length and large CSA)

Principles of Bulk Flow

THESE ARE FACTORS THAT AFFECT THE FLOW OF AIR- NOTICE HOW THEY ARE THE SAME AS THOSE THAT AFFECT THE FLOW OF BLOOD

- Flow from regions of higher to lower pressure
  - Boyle's Law $P_1V_1=P_2V_2$
  - Decreasing volume increases collision & decreases pressure

Spirometer

A person's pulmonary function is assessed by measuring how much air moves during quiet breathing, then with maximum effort. These pulmonary function tests use a spirometer that measures the volume of air moved with each breath.

Principles of Bulk Flow

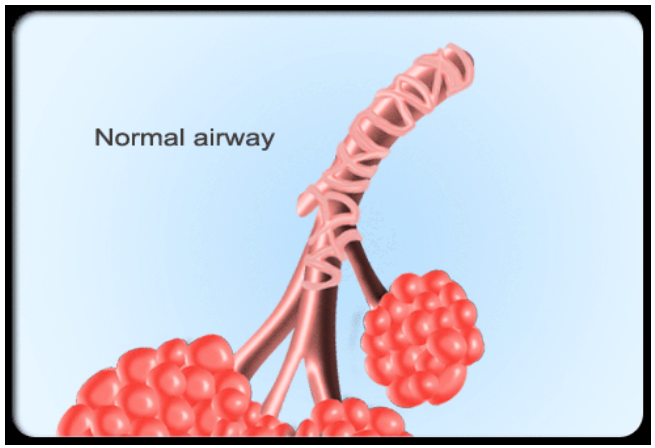
- Breathing is an active process that requires muscle contraction.
- Muscular pump (muscles of thoracic cage and diaphragm) creates pressure gradients
  - Muscular contractions increase or decrease the size of the thoracic cavity, changing the pressure so air moves in or out
  - When muscles contract, lungs expand

Flow α ΔP / R

Air flow in response to a pressure gradient and flow decreases as the resistance increase.

Factors have greater influence on the amount of work needed for breathing are:

Stretchability of the lungs



Resistance of airways

Compliance and Elastance

- **Compliance: ability of the lung to stretch**

The change of volume that results from a given force or pressure

  - **High compliance- Stretches easily-**

  - **Low compliance *Requires more force to stretch***

Compliance and Elastance

- **Elastance (elastic recoil):** ability to turn its original shape when a deforming force is removed.

  The change of pressure that results from a given volume , the reciprocal of elastance

Bronchoconstriction (increases resistance and reduces flow)
Bronchodilation (decreases resistance and increases flow)

As alveolar ventilation increases, alveolar PO_2 increases, PCO_2 decreases. The opposite occurs as alveolar ventilation decreases.

Oxygen Transport

98% of oxygen is bound to hemoglobin and the other 2% is dissolved in plasma

Because oxygen is not easily dissolve in water, hemoglobin is a protein that binds O_2 and dramatically increased the amount of blood in the plasma

The Hemoglobin Molecule

The amount of oxygen bound to hemoglobin depends on the P_{O_2} of plasma- each hemoglobin can carry 4 oxygen molecules, the **% saturation** tells how much is carried.

Regulation of Ventilation

Carotid body oxygen sensor releases neurotransmitter when PO_2 decreases

Regulation of Ventilation

Central chemoreceptors monitor CO_2 in cerebrospinal fluid

CO_2 crosses BBB and activates receptors. These increase the rate and depth of ventilation and enhance ventilation and removes CO_2 .
They actually respond to pH changes in cerebrospinal fluid. CO_2 is converted into carbonic acid which is then dissociates to bicarbonate and H^+.

If all Hb molecules are occupied by oxygen molecules, the blood is 100% oxygenated or saturated.

The amount of oxygen bound to Hb at any given PO_2 is expressed as the percent O_2saturation of hemoglobin.