



# **Cardiopulmonary System**

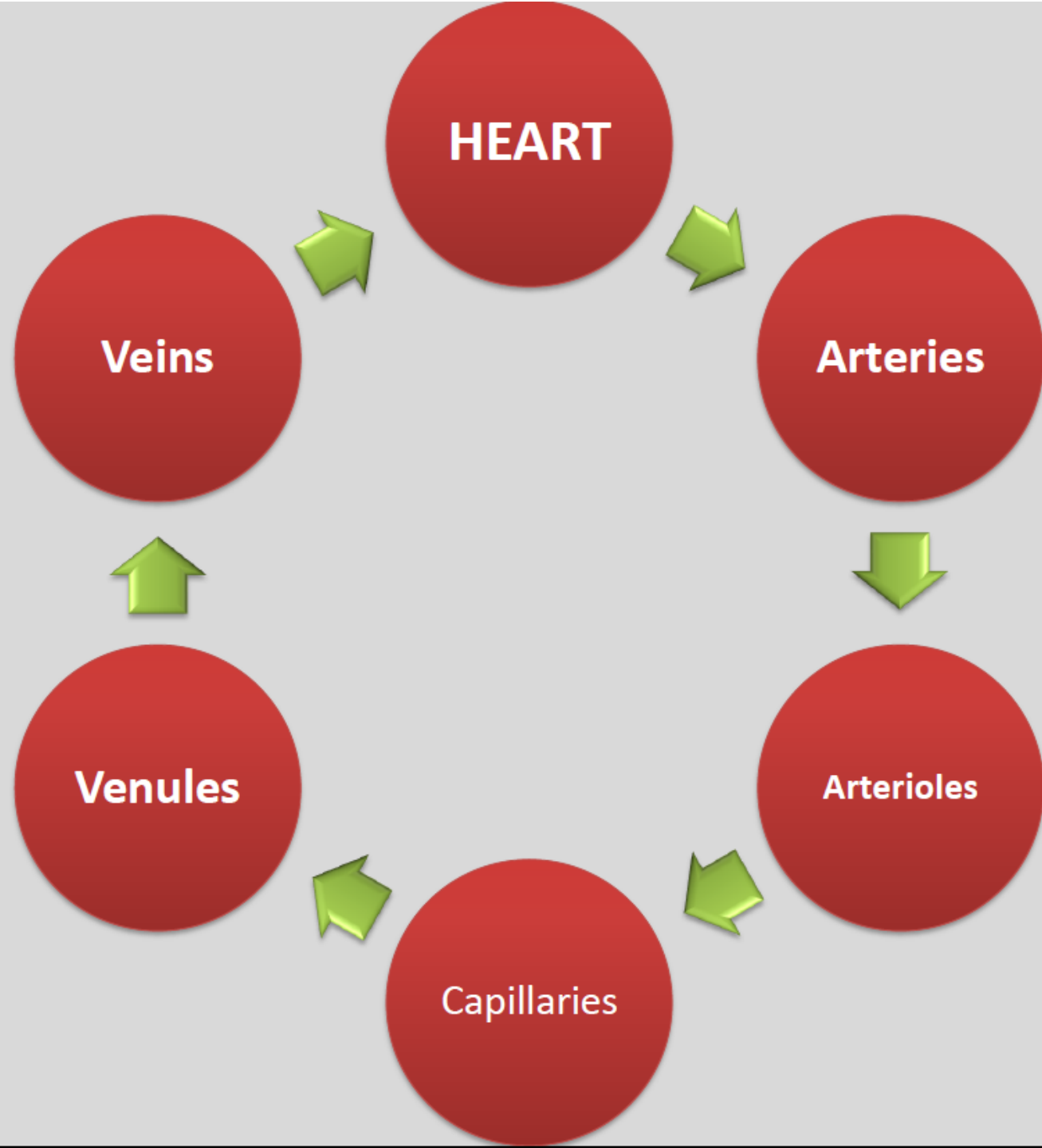
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# Circulatory System

- In order to maintain homeostasis and survive cells;
  - ✓ have to take oxygen and nutrients
  - ✓ have to excrete  $\text{CO}_2$  and metabolic waste products
- Our circulatory system is closed and perpetual.



# Two Distinct Systems

- Systemic circulation:
  - **Left ventricle** → Aorta → All Body.
  - Turns back to right atrium
- Pulmonary circulation:
  - **Right ventricle** → Pulmonary Artery → Lungs
  - Turns back to left atrium

# Structure of the Human Heart

- The heart is consist of four cavities:
  - Two atriums
  - Two ventricles
- Blood enters to heart through atriums, and leaves the heart through the ventricles.
- The arteries which supply blood to myocardium is called «coronary arteries».



# Structure of the Human Heart

- The sac contains the heart and great vessels is called «**pericardium**». It has two layers. . It encloses the pericardial cavity which contains pericardial fluid.
- Heart muscle is called «**myocardium**».
- The epithelium inside the cavities is called «**endocaridum**».

# Structure of the Human Heart

- Right atrium + Right Ventricle = Right Pump
- Left atrium + Left ventricle = Left Pump
- Right and left pump is separated by **interatrial** or **interventricular septum**.
- Septums, prevents mixing of blood between two pumps.

# Structure of the Human Heart

- There is also a barrier between atrium and ventricle but there are valves on this barrier which controls the blood flow.  
(Atrioventricular valves)
  - «**Tricuspid valve**» is between right atrium and right ventricle
  - «**Mitral valve**» is between left atrium and left ventricle



# Structure of the Human Heart

- **The semilunar valves** are located at the exit of aorta (aortic valve) and pulmonary trunk (pulmonary valve).
- Semilunar valves control the passage of blood to the systemic or pulmonary circulation.
- All valves unidirectional and demand a certain pressure for opening.

# Echocardiography (EKO)

- Echocardiography uses standard two-dimensional, three-dimensional, and Doppler ultrasound to create images of the heart.
- An echocardiogram, often referred to as a cardiac echo or simply an echo, is a sonogram of the heart.

# Echocardiography (EKO)

- It can provide helpful information about;
  - The size and shape of the heart (internal chamber size quantification)
  - Valvular morphology
  - Pumping capacity (Estimation of heart function by using Doppler's method)
    - Cardiac output
    - Ejection fraction
    - Diastolic function (how well the heart relaxes).

# Types of Heart Muscles

- There are three types of muscle cells in the heart:
  1. Atrial muscle fibers
  2. Ventricular muscle fibers
  3. Cardiac conduction system

1. Majority of fibers
  2. Contraction
- Cardiac conduction system is consisted of muscle fibers (not neurons).
- Only cardiac conduction system has “pacemaker” activity. Other fibers don't.



# Physiology of the Myocardium

- Cardiac muscle cells;
  - Looks like skeletal muscle cells.
  - But on the contrary of skeletal muscle, they have lots of “gap junctions”.
  - Through these junctions action potential spreads throughout the muscle and whole of the muscular body can be stimulated simultaneously.
  - It is called “functional syncytium”
- Contraction of myocardium is named as “systole”.
- Relaxation of the myocardium is named as “diastole”.



# Cardiac Conduction System

- **Sinoatrial Node (SA Node):** Principal pacemaker of the heart. The source of impulses in normally beating heart.
- **Atrioventricular Node (AV Node):** Delays the impulses right before it passes through ventricles from atria.
- **Bundle of His:** Conducts the atrial impulses to the ventricles.
- **Purkinje System:** Depolarizes the ventricles.

# Electrocardiography (ECG)

- Electrocardiography (ECG) is the process of recording the “**electrical activity of the heart**” over a period of time using electrodes placed on the skin.
- What is the source of this activity?
  - It is NOT the cardiac action potential.

# ECG Leads

- We record the cardiac activity from 12 different channels (Leads).
1. Standard bipolar limb leads:
    - I / II / III
  2. Augmented unipolar limb leads:
    - aVR / aVL / aVF
  3. Precordial (chest) leads:
    - $V_1 / V_2 / V_3 / V_4 / V_5 / V_6$

# ECG Waves

- **P Wave:** Atrial depolarization
- **QRS Complex:** Ventricular depolarization
- **T Wave:** Ventricular repolarization
- **Segments and intervals**

# Cardiac Innervation

Sympathetic Activity



Heart Rate  $\uparrow$   
(+) chronotropic

Contractility  $\uparrow$   
(+) inotropic



CARDIAC OUTPUT  $\uparrow$

Parasympathetic Activity



Heart Rate  $\downarrow$   
(-) chronotropic

Contractility  $\downarrow$   
(-) inotropic



CARDIAC OUTPUT  $\downarrow$



# Respiratory Physiology

# Respiratory System

- Respiratory system is a biological system consisting of specific organs (<sup>1</sup>lungs and <sup>2</sup>respiratory tract) which are responsible of gas exchange in the human body.
- Other functions:
  - Regulating pH of the organism
  - Defense against microorganisms
  - Phonation (Making sound for speaking)

# Respiratory Tract

- **“Upper Respiratory Tract”** consists of;
  - The nasal cavity and paranasal sinuses,
  - The pharynx (nasopharynx, oropharynx and laryngopharynx)

# Respiratory Tract

- **“Lower Respiratory Tract”** consists of;
  - The trachea,
  - Bronchi (primary, secondary and tertiary),
  - Bronchioles (including terminal and respiratory),
  - Alveoli

# Respiratory Tract

- The **trachea** is the largest tube in the respiratory tract and consists of tracheal rings of "hyaline cartilage".
- It branches off into two bronchial tubes, a left and a right main "**bronchus**".
- The bronchi branch off into smaller sections inside the lungs, called "**bronchioles**". These bronchioles give rise to the air sacs in the lungs called the "**alveoli**".



- **Conducting Zone**  
(Anatomic Dead Space):
  - No gas exchange is possible in these spaces.  
(≈150 ml)
  - Mouth to terminal bronchioles
- **Respiratory Zone:**
  - Gas exchange is possible

# Microanatomy of Respiratory Tract

- The respiratory tract is covered inside by **epithelium**,
- Most of the epithelium (from the nose to the bronchi) is covered in **ciliated** pseudostratified columnar epithelium, commonly called respiratory epithelium.
- The cilia beat in one direction, moving mucus towards the throat where it is swallowed
- There are glands and **mucus** produced by goblet cells

# Control of Respiratory Tract

- The muscles of respiratory tract (area with no cartilage) is innervated by autonomic nervous system;
  - **Parasympathetic system** induces contraction in these muscles and makes “bronchoconstriction”
  - **Sympathetic system** induces relaxation in these muscles and makes “bronchodilatation”

# Lungs

- The "**lungs**" are the largest organs in the lower respiratory tract.
- The lungs are suspended within the "**pleural cavity**" of the thorax.
- The "**pleurae**" are two thin membranes, one cell layer thick, which surround the lungs. The inner (visceral pleura) covers the lungs and the outer (parietal pleura) lines the inner surface of the chest wall.
- There is "**intrapleural fluid**" between these membranes and it has negative pressure which prevents the collapse of the lung. If this pressure is lost lung collapses (pneumothorax)
- The lungs are divided into different lobes. The right lung is larger in size than the left, because of the heart's being situated to the left of the midline



# Alveolus

- **Alveolus** (plural: **alveoli**) is a hollow cavity found in the lung, and is the basic unit of ventilation. It is the main place in which gas exchange occurs.
- Each alveolus is wrapped in a web of capillaries covering about 70% of its area.
- A typical pair of human lungs contain about 700 million alveoli, producing 70m<sup>2</sup> of surface area
- There are three major types of cell in the alveolar wall:
  - **Type I cells** are thin and flat and form the structure of the alveoli
  - **Type II cells** secrete "surfactant"
  - **Alveolar macrophages**
- **Surfactant** lowers the surface tension of water and allows the membrane to separate, therefore prevents collapse of the alveolus.



# Respiratory Cycle

- Respiratory Cycle = Inspiration + Expiration
  - **Inspiration:** Movement of air from atmosphere to lungs.
  - **Expiration:** Movement of air from lungs to atmosphere.

# Respiratory Rate

- Adults:
  - 12-16 /minute
- Newborns (0-6 months):
  - 30-60 /minute
- **Apnea:** Suspension of breathing
- **Tachypnea:** Abnormally rapid breathing
- **Bradypnea:** Abnormally slow breathing

# Ventilation

- **Ventilation**, is the process of moving air in or out.
  - “Pulmonary ventilation” is the ventilation of the lungs.
    - $V_p = \text{Normal Breath Volume} \times \text{Breath Rate}$ 
      - $V_p = 500 \text{ ml} \times 12 = 6000 \text{ ml/min}$
  - “Alveolar ventilation” is the ventilation of the alveoli.
    - $V_A = (500 \text{ ml} - 150 \text{ ml}^*) \times 12 = 4200 \text{ ml/min}$
    - \* *Anatomic Dead Space*

# Pulmonary Function Tests

- Spirometry, is one of the most used tool to evaluate pulmonary function.
  1. Static Tests (*Lung Volumes and Capacities*)
  2. Dynamic Tests
  3. Maximal Voluntary Ventilation

# Lung Volumes and Capacities

- Residual volume cannot be measured by spirometry.
- Residual volume can be measured via “Helium dilution method”.



# Dynamic Testing

- **Obstructive** lung disease is a category of respiratory disease characterized by airway obstruction.
- **Restrictive** lung disease is a category of respiratory disease that restrict lung expansion.
- $FEV_1\% = FEV_1 / FVC$ 
  - If  $FEV_1\% > 80\%$ , patient is not obstructive
  - If  $FEV_1\% < 80\%$ , patient has obstruction.
- Restriction cannot be diagnosed with  $FEV_1\%$  value.

**Thank You...**