Heart

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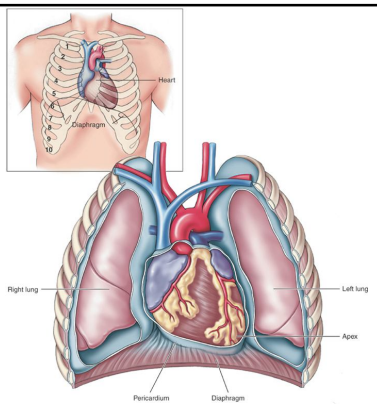
Heart

- The heart is a hollow muscular organ about the size of a closed fist
- Sits inside the chest within the mediastinum, between the lungs
- Lies toward the left side of the body
- Flat upper portion is located at the level of the 2nd rib
- The apex (lower portion) is located at the level of the 5th & 6th rib
- Lies within & is supported by the pericardium



Heart

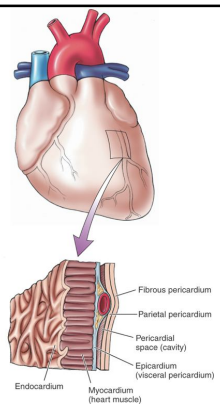
- Function of the heart is to pump blood through the blood vessels of the body, providing oxygen & nutrients to all cells
- The heart pumps on average 72 times/minute

Layers of the Heart

- Heart is made up of 3 layers:
  - Endocardium:
    - Innermost layer composed of thin layer of simple squamous epithelium over a layer of connective tissue
    - Smooth & shiny surface allows blood to flow easily
    - Lines valves & vessels entering & leaving heart

Layers of the Heart

- Myocardium:
  - Thick middle layer
  - Thickest of all layers composed of cardiac muscle tissue (actin, myosin & intercalated discs)
  - Allows the heart to contract, propelling blood through blood vessels
- Epicardium:
  - Thin outermost layer
  - Continuous at apex with the inner lining of the pericardium



Heart

- Pericardium:
  - Sling like structure that supports the heart & attaches the heart to sternum & diaphragm
- Pericardial space:
  - serous membrane located between the epicardium & pericardium
  - serous membrane secretes serous fluid (pericardial fluid) that lubricates the surfaces of the membranes allowing them to slide past one another without rubbing or friction

Heart

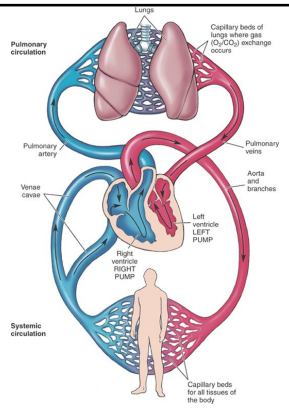
- Two pumps & two circulations:
- The pumps are the:
  - left side of the heart
  - right side of the heart
- The two circulations are:
  - pulmonary circulation
  - systemic circulation

Circulation

- The right side of the heart:
  - Receives deoxygenated blood from the superior & inferior vena cava
  - Pumps blood to the lungs where the blood is oxygenated
  - The blood travels from the right side of the heart to the lungs then back to the left side of the heart
  - This path is called pulmonary circulation
  - Only function of pulmonary circulation is to circulate the blood to the lungs for oxygen & to rid the body of carbon dioxide

Circulation

- The left side of the heart:
  - Receives the oxygenated blood from the lungs & pumps out the aorta to all the organs of the body
  - The path the blood take from the left side of the heart to the organs of the body & then back to the right side of the heart is called systemic circulation



Chambers of Heart

- Heart has 4 chambers:
  - 2 atria & 2 ventricles
- The atria:
  - Right & Left Upper chambers of heart
  - Receive blood
- The ventricles:
  - Right & Left Lower chambers of heart
  - Pump blood out of heart

Chambers of Heart

- Right & Left heart are separated by septum
  - Interatrial septum separates atria
  - Interventricular septum separates ventricles

Chambers & Vessels

- Right atrium:
  - Is thin-walled cavity
  - Receives deoxygenated blood from large veins
  - Superior vena cava collects blood from the heart & upper body region
  - Inferior vena cava receives blood from the lower part of the body

Chambers & Vessels

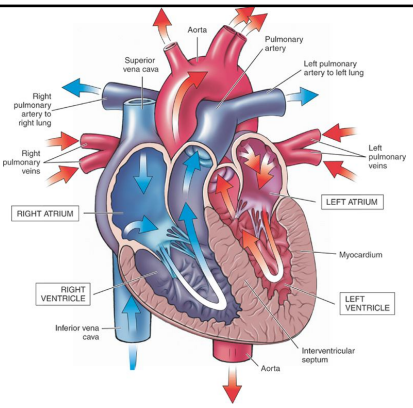
- Right Ventricle:
  - Receives deoxygenated blood from the right atrium
  - Pumps blood to lungs through the pulmonary artery
  - Pulmonary artery splits into right & left branches delivering blood to the right & left lung
  - Main function of right ventricle is to pump blood to the lungs

Chambers & Vessels

- Left Atrium:
  - Thin walled cavity
  - Receives oxygenated blood from the lungs through the 4 pulmonary veins

Chambers & Vessels

- Left Ventricle:
  - Receives oxygenated blood from the left atrium
  - Primary function is to pump blood into systemic circulation
  - Blood leaves the left ventricle through the aorta
  - Thick walled cavity needed to generate enough force to pump the blood out of the heart into systemic circulation



Heart Valves

- The purpose of heart valves is to keep the blood flowing in a forward direction
- 4 valves
  - 2 valves are located between the atria & ventricles are called **atrioventricular valves** or AV valves called entrance valves
  - 2 other valves are called **semilunar valves** which are considered exit valves

Heart valves

- Atrioventricular Valves:
  - Located between the atria & ventricle on each side to the heart
  - Have cusps or flaps
  - When ventricles are relaxed, cusps hang loose allowing valves to open permitting blood flow from atria to ventricles
  - When ventricles contract, the heart muscle squeezes blood into ventricles pushing cusps upward toward atria in a closed position
  - The AV valves prevent backward blood flow from the ventricles into the atria

Heart Valves

- Cusp are attached to the ventricular wall by a tough fibrous band called chordae tendineae
- As blood pushes the cusps into a closed position, the chordae tendineae are stretched to full length
- The stretched chordae tendineae hold onto the cusps & prevent them from being pushed into the atria

Heart Valves

- Right Atrioventricular Valve:
  - Called ***tricuspid valve*** because it has 3 cusps
  - Located between the right atria & right ventricle
  - When tricuspid opens, blood flows freely from the right atrium into the right ventricle
  - When the right ventricle contracts, the tricuspid valve closes preventing the blood from flowing back into the right atrium

Heart Valves

- Left atrioventricular Valve:
  - Called the bicuspid valve because it has 2 cusps
  - It is also called the mitral valve
  - Located between the left atrium & left ventricle
  - When the mitral/bicuspid valve is open, blood flows from the left atrium into the left ventricle
  - When the left ventricle contracts, the mitral/bicuspid valve closes preventing the backflow of blood into the left atrium

Heart Valves

- Semilunar Valves:
  - Considered exit valves
  - 2 types:
    - Pulmonic valve
    - Aortic valve

Heart Valves

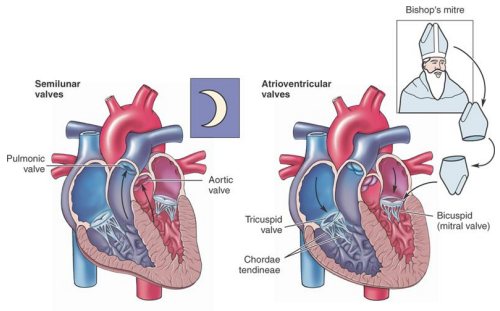
- Pulmonic Valve:
  - Also called right semilunar valve
  - Located between the right ventricle & the pulmonary artery
  - When the right ventricle relaxes, the valve is in a closed position
  - When the right ventricle contracts, blood from the ventricle forces the pulmonic valve open
  - Blood then flows through the open valve into the pulmonary artery & into the lungs
  - When the right ventricle relaxes, the pulmonic valve snaps closed & prevents the blood from returning to the right ventricle

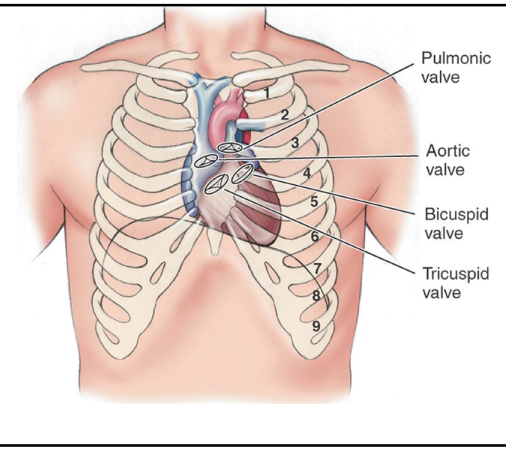
Heart Valves

- Aortic Valve:
  - Also called left semilunar valve
  - Located between the left ventricle & aorta
  - When the left ventricle relaxes, the valve is in a closed position
  - When the left ventricle contracts, blood from the ventricle forces the aortic valve to open
  - Blood flows through the aortic valve into the aorta
  - When the left ventricle relaxes, the aortic valve snaps closed preventing backflow from the aorta into the ventricle

Heart Valves

- Semilunar Valves close when the pressure in the pulmonic artery & aorta become greater than the pressure in the ventricles
- Blood from great vessels gets behind the valves & snaps them closed
- The closed semilunar valves prevent the backward flow of blood from the pulmonary artery & aorta into the ventricles





Heart Sounds

- Vibrations caused by the closure of the valves are heart sounds
- The first heart sound, ***lubb,*** is due to the closure of the AV valves at the beginning of ventricular contraction
- The second heart sound, ***dupp***, is due to the closure of the semilunar valves at the beginning of ventricular relaxation
- Murmurs are abnormal heart sounds due to pathology of valves

Pathway of Blood

Unoxygenated blood enters the right atrium from the superior & inferior vena cave

↓

Right Atrium

↓

Tricuspid Valve

↓

Right Ventricle

↓

Pulmonic Valve

↓

Pathway of Blood

Pulmonary artery (right & left)

↓

Pulmonic circulation/Lungs

↓

4 Pulmonary Veins

↓

Left Atrium

↓

Pathway of Blood

Bicuspid/ Mitral Valve

↓

Left Ventricle

↓

Aortic Valve

↓

Aorta

↓

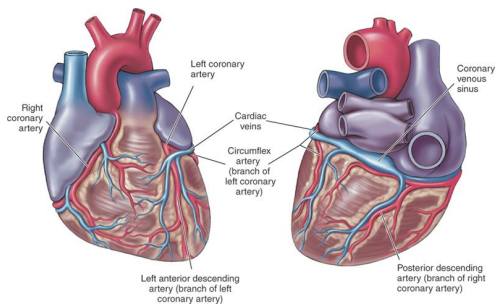
Systemic Circulation

Myocardium Blood Supply

- The myocardium of the heart receives its blood supply from the coronary arteries
- Coronary arteries arise from the aorta just above the aortic valve
- Two main arteries are:
  - Left & Right coronary artery

Coronary Arteries

- Right coronary artery nourishes the right side of the heart, esp. Right ventricle
- Left coronary artery branches into the left anterior descending artery & the circumflex artery which nourish left side of heart, esp. Left ventricular wall
- Coronary veins collect blood that nourishes the myocardium & carries it to the coronary sinus which empties into the right atrium



Cardiac Conduction System

- An electrical signal stimulates the heart muscle to contract & coordinates the pumping activity of the atria & ventricles
- Both atria contract at same time followed by simultaneous contraction of both ventricles
- The conduction system is located in the walls of the heart & in the septum that separates the right & left heart

Cardiac Conduction System

- Conduction System consists of:
  - Sinoatrial node
  - Atrial conducting fibers
  - Atrioventricular node
  - Bundle of His
  - Purkinje System

Cardiac Conduction System

- Sinoatrial Node:
  - Pacemaker of the heart
  - Located in the upper posterior wall of the right atrium
  - Electrical signal called cardiac impulse starts in the SA node
  - SA node fires 60-100 cardiac impulses/minute (average 72)

Cardiac Conduction System

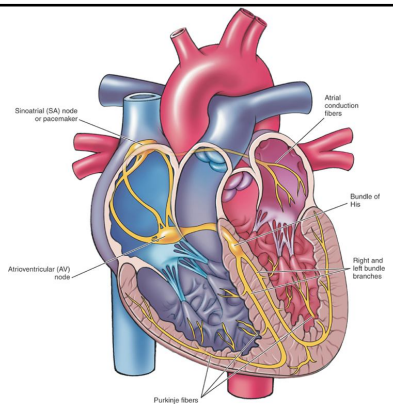
- Atrial Conducting Fibers
  - Cardiac impulse travels from the SA node through both atria along the atrial conducting fibers
- Atrioventricular Node:
  - Located in the floor of the right atrium, near the interatrial septum
  - Cardiac impulse travels from the SA node across the atrial fibers to the AV node

Cardiac Conduction System

- Bundle of His:
  - Once the impulse moves through the AV node it slows & travels to the Bundle of His
  - Bundle of His is specialized conduction tissue located in the interventricular septum
  - The slowing of the impulse through the AV node delays ventricular activation which allows the relaxed ventricle to fill with blood after the atrial contraction

Cardiac Conduction System

- Bundle of His:
  - Two branches:
    - Right & Left Bundle Branches
  - Along these branches are numerous long fibers called Purkinje Fibers
  - Purkinje Fibers are distributed throughout the ventricular myocardium & conduct cardiac impulses very rapidly throughout the ventricles ensuring coordinated contraction of both ventricles



Sinoatrial Node

↓

Atrial conducting fibers

↓

Atrioventricular Node

↓

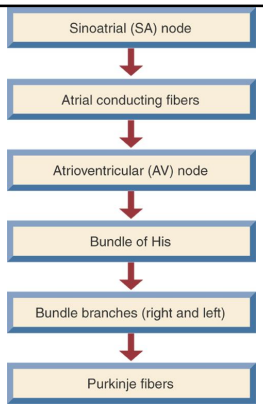
Bundle of His

↓

Bundle Branches(right & left)

↓

Purkinje Fibers



Cardiac Tissue

- Cardiac tissue creates impulses because of:
  - automaticity & rhythmicity
- Automaticity: cardiac impulses arise within the cardiac tissue itself; no extrinsic nerve or factors
- Rhythmicity: cardiac impulses are fired regularly; the heart has rhythm

Wandering Pacemaker

- When an impulse is fired from an area outside the SA node, it is said to be a wandering pacemaker
- Called ectopic focus because it causes an ectopic beat
- At times the AV node will fire a cardiac impulse
- When an impulse comes from an area other than the SA node it can cause serious dysrhthymias

Electrocardiogram

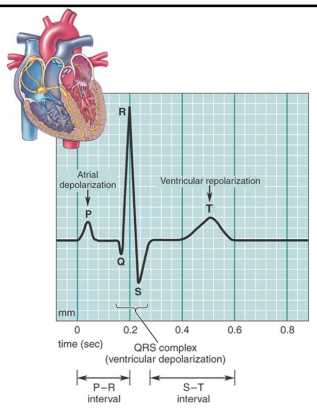
- Electrical activity of the heart can be measured by placing electrodes on the surface of the chest & performing an Electrocardiogram
- Components of test include:
  - P wave
  - QRS complex
  - T wave
  - P-R interval

Electrocardiogram

- P Wave:
  - Atrial depolarization
  - Inflow of sodium ions make the inside of the cell positive
  - Depolarization precedes & triggers contraction of the heart muscle
- QRS complex:
  - Reflects the electrical activity related to ventricular depolarization

Electrocardiogram

- T wave:
  - Reflects electrical activity related to ventricular repolarization; return of the cell to a resting state where the inside is negative
- P-R interval
  - Represents the time it takes for the cardiac impulse to travel for the atria (P wave) to the ventricles (QRS complex)



Cardiac Cycle

- Cardiac Cycle
  - is the sequence of events that occur during one heart beat
  - Coordinated contraction & relaxation of the chambers of the heart
- Systole:
  - Contraction of the heart muscle
  - Systole squeezes blood out of a chamber
- Diastole:
  - Relaxation of the myocardium
  - During diastole blood fills the chambers

Cardiac Cycle

- Atrial Systole:
  - Atria contract & blood is pumped into ventricles; AV valves are open & ventricles are relaxed
- Ventricular Systole:
  - At the end of atrial systole, the ventricles contract
  - Blood is forced against the AV valves causing them to close
  - Blood is pushes the semilunar valves open allowing blood to flow into pulmonary artery & aorta

Cardiac Cycle

- Diastole:
  - For a brief period during the cardiac cycle, both the atria & ventricles are in diastole
  - As the chambers relax, blood flows into the atria
  - Since the AV valves are open much of the blood passively flows into the ventricle
  - This is a period of filling
  - Atrial systole follows
  - The cycle repeats

Cardiac Output

- Cardiac output is the amount of blood pumped by each ventricle in 1 minute
- Normal output is 5 liters per minute
- The entire blood volume pass through the heart every minute
- Cardiac output is determined by two factor:
  - Heart rate & Stroke Volume
- CO = HR x SV
- Cardiac output can be increased by increasing the HR &/or SV

Heart Rate

- Heart rate:
  - Is the number of times the heart beats in a minute
  - Reflects the firing of the SA node
  - Normal adult HR is 60-100
  - Average 72
  - Heart rate differs for various reasons:
    - Size—gender—age—exercise—hormones—stimulation of automonic nervous system—pathology—medication

Heart Rate

- Size: larger the size, the slower the rate; related to metabolism
- Gender: women's are faster than men
- Age: the younger the person, the faster the rate
- Exercise: increase in activity causes and increase in HR; pulse less at rest
- Autonomic nervous system: stimulation of sympathetic increases HR; stimulation of parasympathetic slows the HR

Heart Rate

- Hormonal influence:
  - Epinephrine & norepinephrine
  - Thyroid hormone
- Pathology:
  - Issues within cardiac conduction itself
- Medications:
  - Certain drugs affect the HR

  Digitalis ↓ HR Caffeine ↑ HR
- Variation in Heart Rate
  - Tachycardia: HR greater than 100
  - Bradycardia: HR less than 60

Stroke Volume

- Stroke volume is the amount of blood pumped by the ventricle per beat
- Average resting stroke volume is 60-80 ml per beat
- The ventricles normally pump out only 65% of the blood in the ventricles
- Greater force of contraction can increase stroke volume & the greater amount of blood pumped in one minute
- Two ways stroke volume can be affected:
  - Starling's law & Inotropic effect

Starling's Law

- Starling's law of the heart depends on the degree of stretch of the myocardial fibers
- The greater the stretch, the stronger the force of contraction
- Increase in the amount of blood entering the ventricles causes the ventricles to stretch
- This stretch increases the force of contraction
- Increase in force of contraction will increase stroke volume

Inotropic Effect

- Positive inotropic effect:
  - stimulation of heart by the sympathetic nerves can increase force of contraction therefore increasing stroke volume
  - Certain hormones & medications can also do this
- Negative inotropic effect:
  - Decreases force of contraction which decreases stroke volume
  - Pathology of the heart & certain medications can cause negative inotropic effect