

MEDAVIE

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CARDIOVASCULAR

ANATOMY

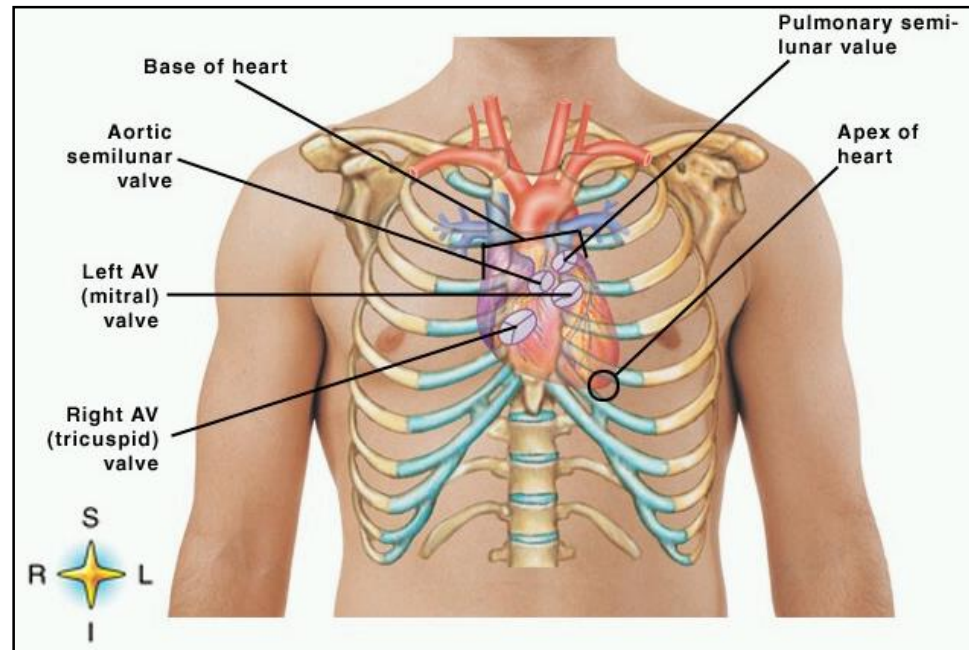
Advanced Care Paramedicine

Module: 07

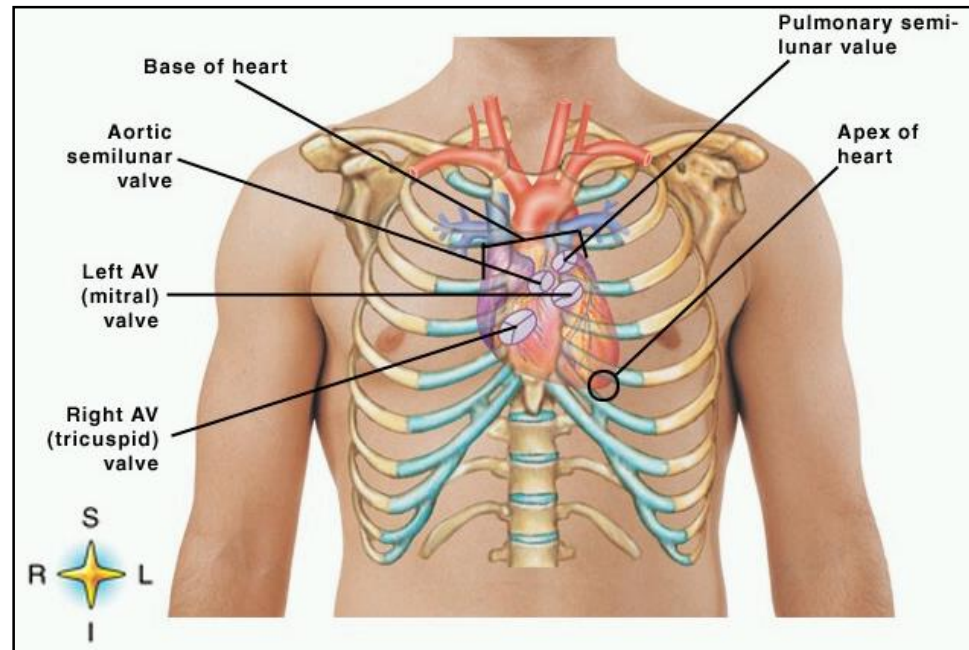
Section: 01

- Contains the organs for circulation
- Includes:
 - Heart
 - Vessels
 - Veins
 - Arteries
 - Capillaries
 - Blood
- Is a closed system

- Two muscular pumps
- Provides the necessary force to circulate the blood to the tissues
- On average the adult heart pumps 5 L/min



- Located in the mediastinum:
 - Posterior to the sternum
 - Rests on diaphragm, 2/3 left of midline
 - The apex is directed inferiorly, anteriorly and to the left (5th intercostal space)
 - The base has several large vessels attached and extends to the 2nd intercostal space
 - On average 9 - 12 cm long



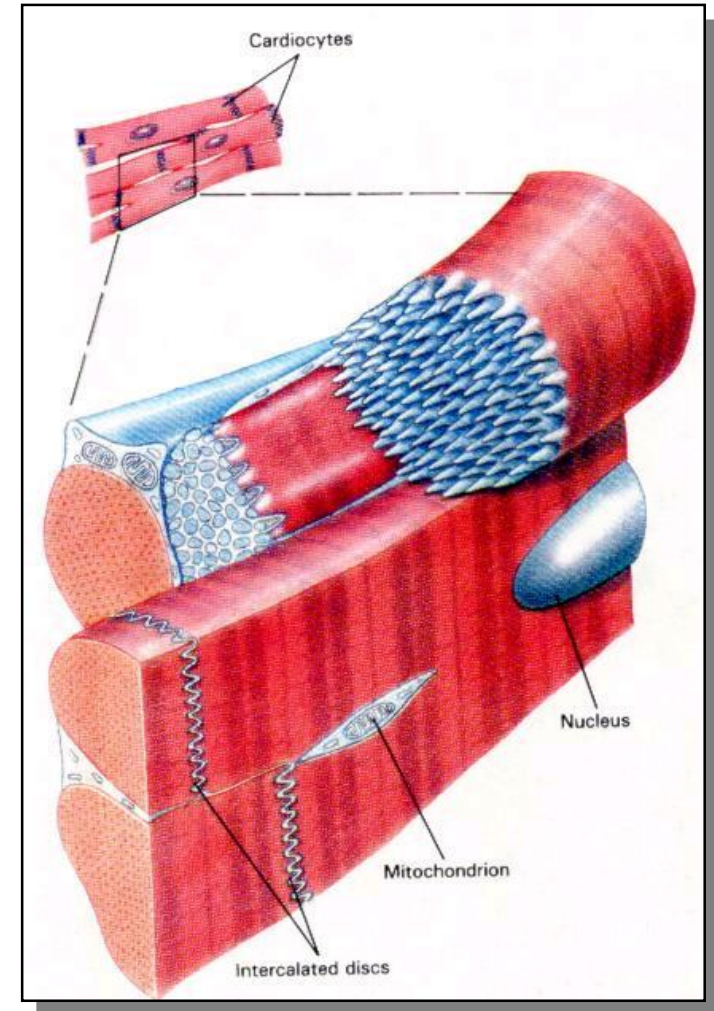
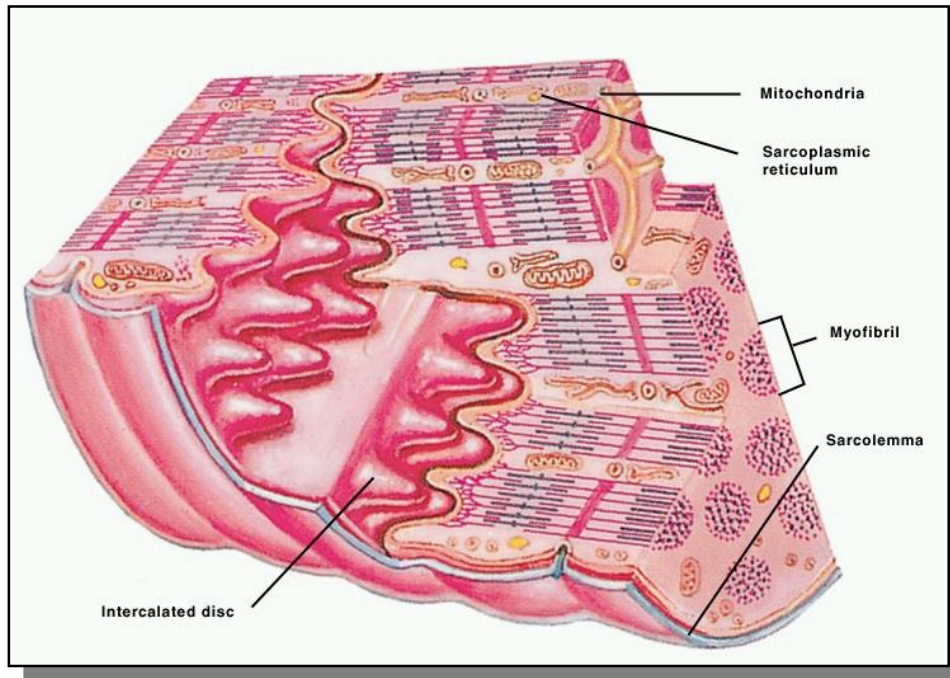
- 2 layer sac that covers the heart
- Fibrous pericardium
 - Outer layer formed of tough white fibrous connective tissue
 - Attached to the large vessels at the base of the heart, diaphragm, sternum and vertebrae
- Serous pericardium
 - Fibrous layer lined with serous membrane called parietal pericardium
 - Inner layer is visceral pericardium (epicardium)
 - Potential space between them is the pericardial cavity
 - Contains pericardial fluid (10 – 15 ml) secreted by the serous membranes

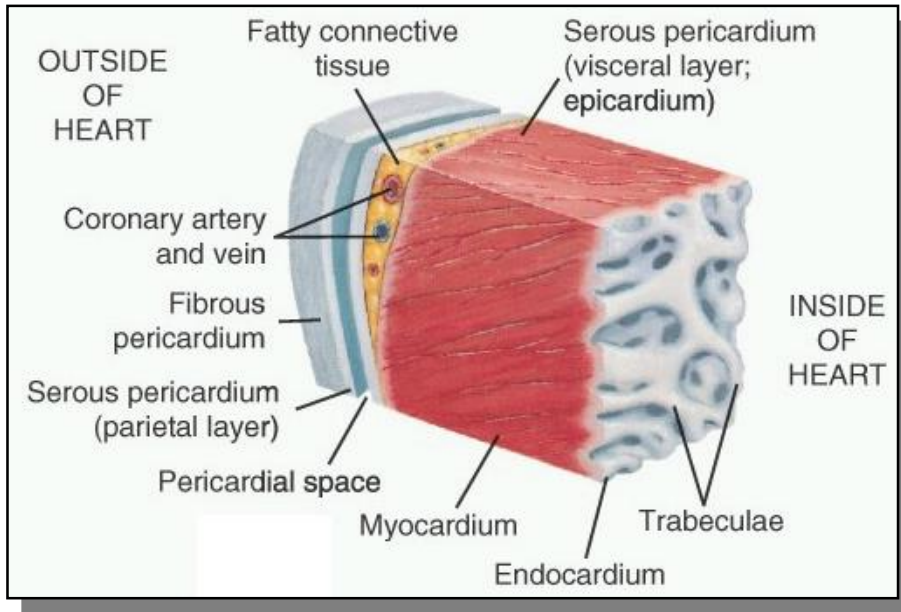
- 3 distinct layers
 - Epicardium
 - Myocardium
 - Endocardium

- Outer layer firmly anchored to the underlying muscle
- Thin protective layer
- Vessels that nourish the heart are located here

- Thick middle layer formed of special cardiac tissue
 - Have the following characteristics
 - Automaticity
 - Excitability
 - Contractility
 - Conductivity
 - Can not summate contractions (tetanus) so do not fatigue
- Branching cells are connected by intercalated discs
- Each disc contains many gap junctions allowing for large amounts of cardiac muscle to be coupled into a single unit (syncytium)
- This allows for action potential to be passed along a large area of the heart wall
- Wrap around the heart in a spiral fashion

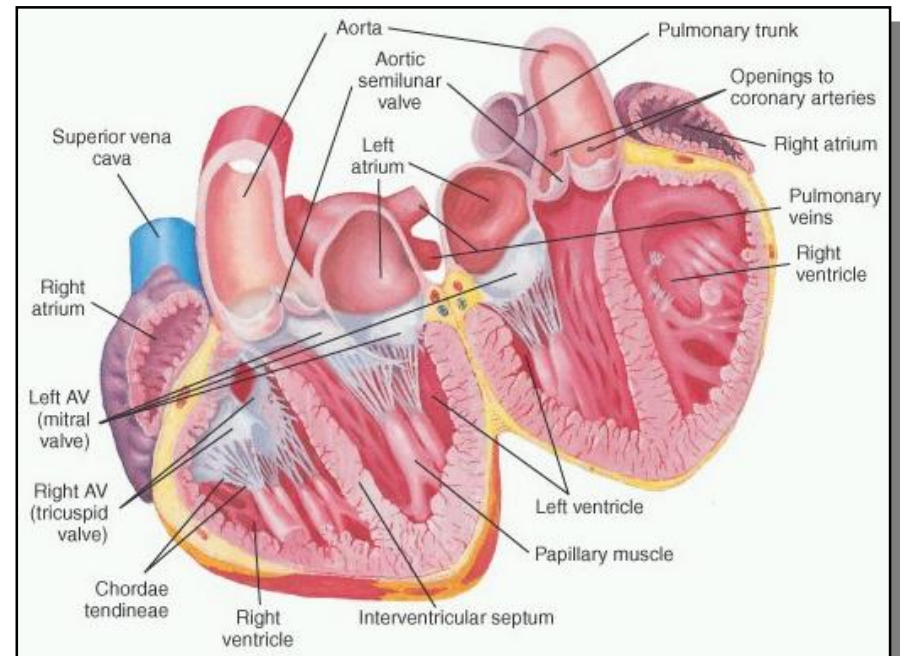
Intercalated Discs





- Inner smooth endothelium layer
- Also forms the valves of the heart
- Is continuous with the lining of the blood vessels
- Contains muscular projections called Trabeculae
- Help regulate flow of blood through chambers

- Four chambers
 - Right and left atria
 - Thin walled chambers
 - Receives blood from the veins
 - Right and left ventricles
 - Thick walled chambers
 - Sends blood through the arteries
- Separated from right to left by the septum



- Receives blood from the veins
- Myocardial layer is thin
- Both atria have small extensions called auricles
- Are divided by Rt to Lt by interatrial septum
 - A thin region, the fossa ovalis, of the interatrial septum represents the foramen ovale that existed during the fetal stage
- Right Atrium
 - Receives deoxygenated blood from the inferior and superior vena cava as well as the coronary sinus
- Left Atrium
 - Receives oxygenated blood from the lungs through the four pulmonary veins

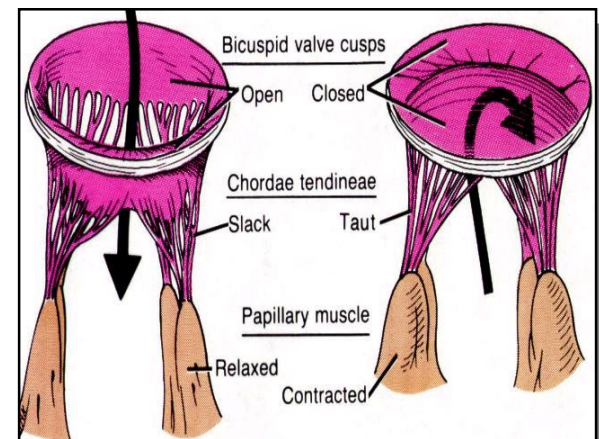
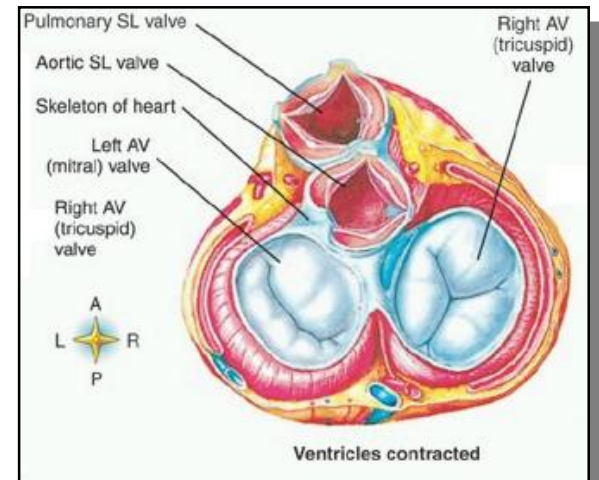
- Receives blood from the atria above
- Thicker myocardial layers (left is thickest)
- Are divided by interventricular septum
- Also have papillary muscles projecting from the wall

- Right Ventricle
 - Receives deoxygenated blood from the right atrium and pumps it to the lungs

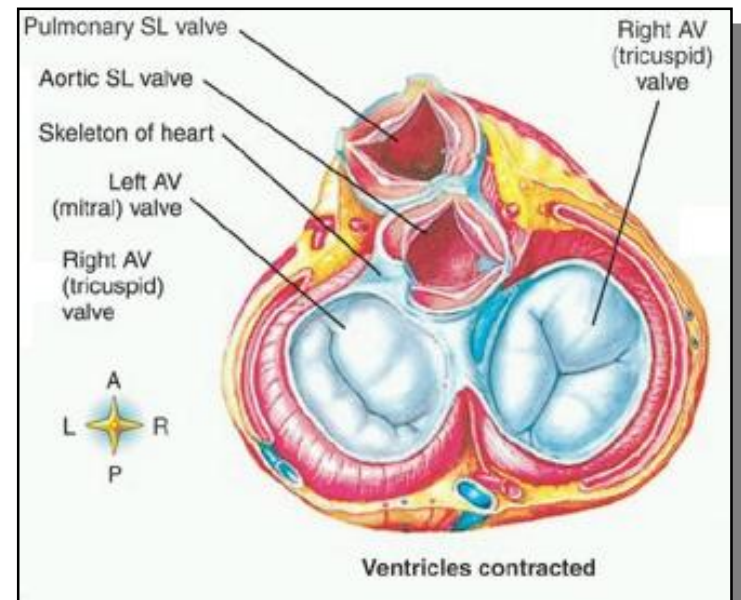
- Left Ventricle
 - Receives oxygenated blood from the left atrium and pumps it to the body

- Mechanical devices that permit the flow of blood
 - Atrioventricular Valves (Cuspid Valves)
 - Semilunar Valves

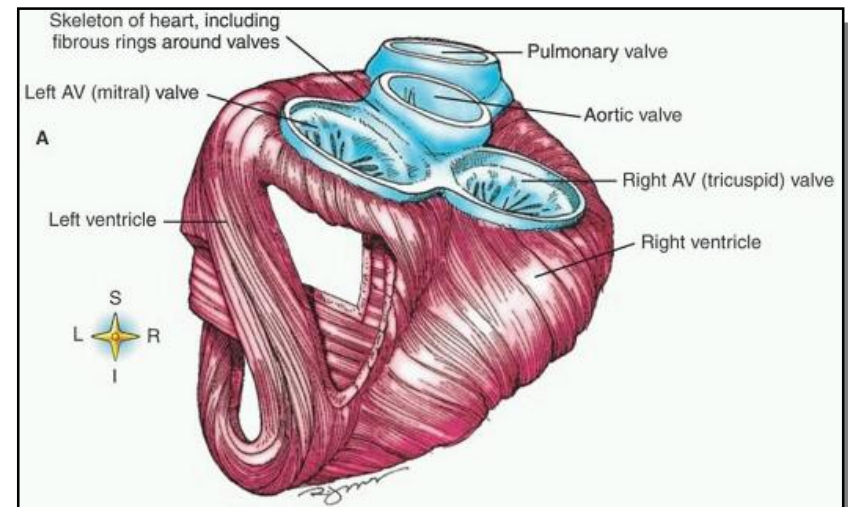
- Between the atrium and the ventricles
 - Tricuspid Valve (Right)
 - Bicuspid (Mitral) Valve (Left)
- Free edges are attached to papillary muscles by chordae tendineae
- Forced open as blood returns to atria, and closed when the ventricles contract



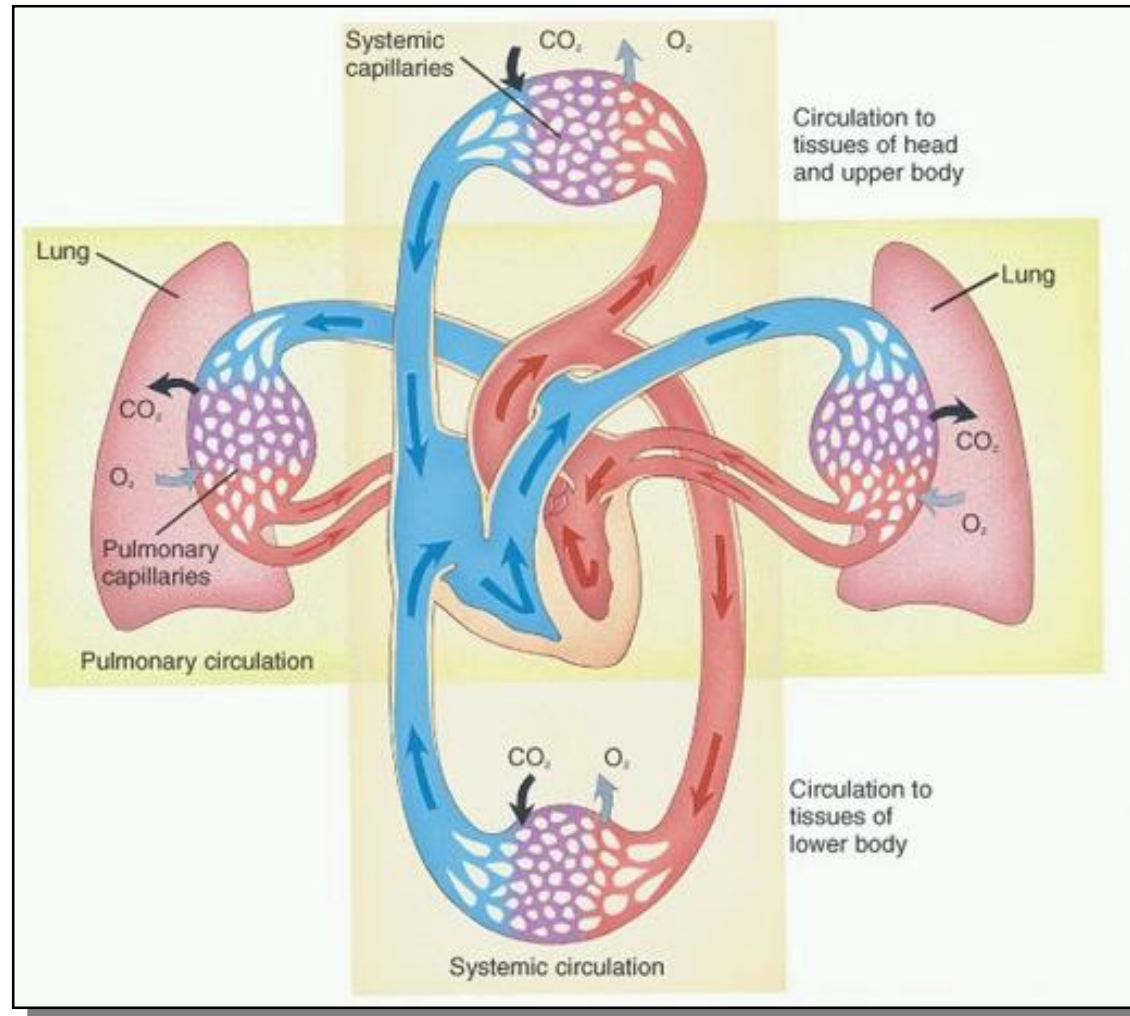
- Located at the bases of the large vessels attached to the ventricles (Aorta and Pulmonary Artery)
- Half-moon flaps grown from the linings of the large vessels
- Open as pressure increases with contraction of the ventricles and forced closed as blood flows back into the “cups”



- Fibrous structure
- Connective rings serving as support for the heart valves and point of attachment for myocardium
- Also serves as an electrical barrier

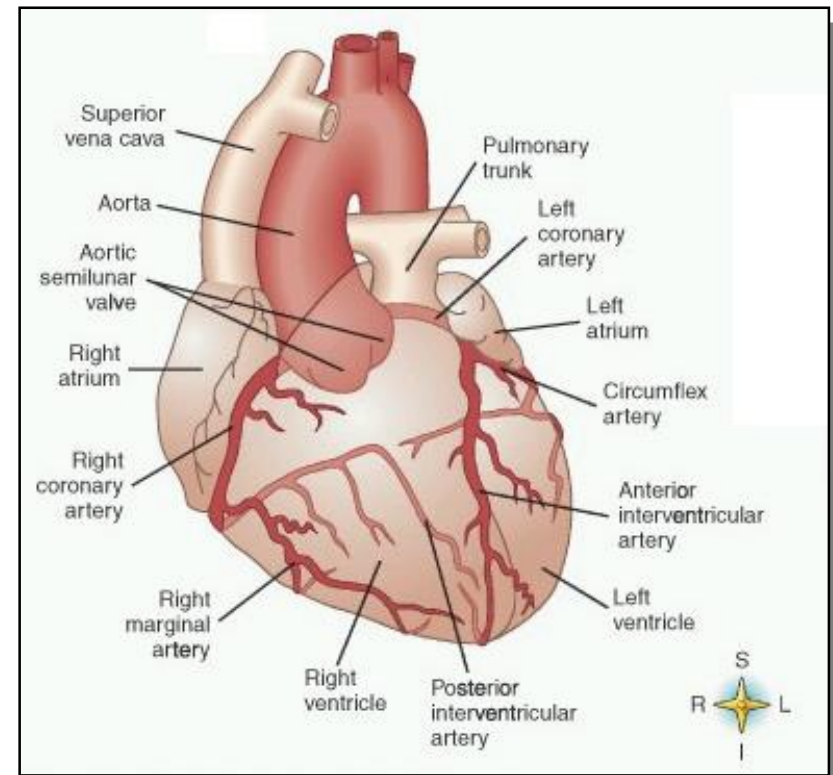


- Right Pump (Pulmonary Circulation)
 - Blood returns to the RA from systemic circulation
 - Passes the tricuspid valve and enters the RV
 - RV sends blood to the lung to be oxygenated through the pulmonary SL valves into the pulmonary arteries
- Left Pump (Systemic Circulation)
 - Returns from lungs through pulmonary veins into LA
 - Passes Mitral valve into the LV
 - Passes the aortic SL valve into the ascending aorta to the body



- Two main coronary arteries branch from the ascending aorta
- Lies behind the flaps
- Blood flow is greatest when the heart is at rest, compression of the ventricles reduces flow
- Limited number of anastomosis
- Provide collateral circulation

- Right Coronary Artery
 - Continues to the Right AV sulcus and to the posterior portion of the heart
 - Supplies most of the right ventricle
- Left Coronary Artery
 - Extends left for 2 cm then divides
 - Anterior Interventricular (Descending) Artery (Aka LAD)
 - Circumflex Artery (Which continues around to the posterior portion of the heart)



- Both ventricles receive blood from branches of the Rt and Lt coronary arteries
- Atrium receive blood from corresponding artery
- RCA is dominant in 50 %, LCA is dominant in 20 %

RCA

- RA
- RV
- Inferior LV
- Posterior wall (90 %)
- SA (50 %)
- AV (90 %)

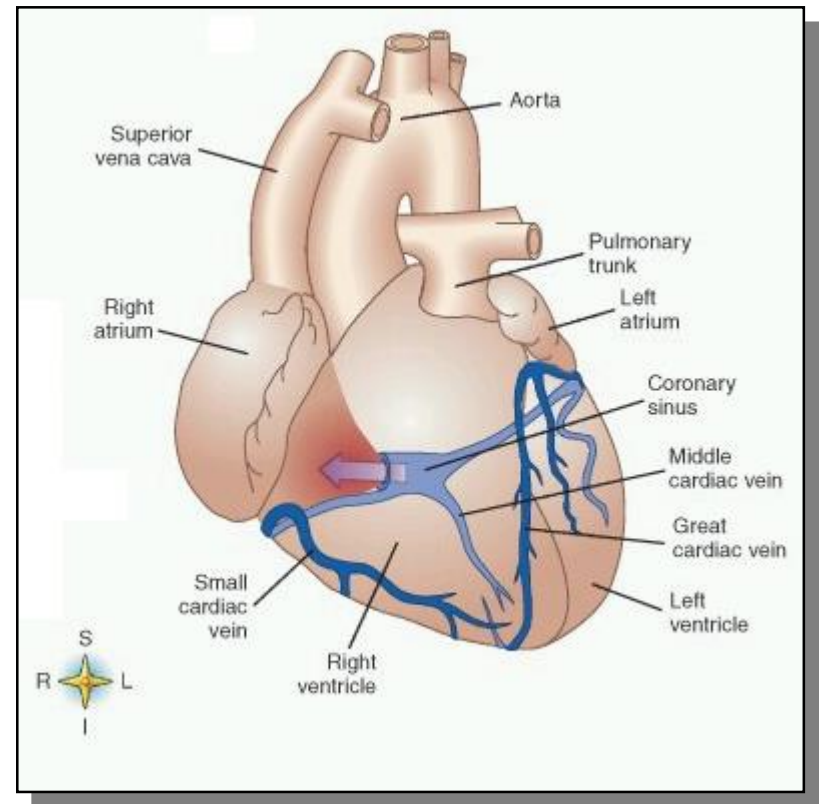
LCA

- LAD gives anterior LV
- IV Septum
- Bundle of HIS
- Right Bundle branch

L Circumflex

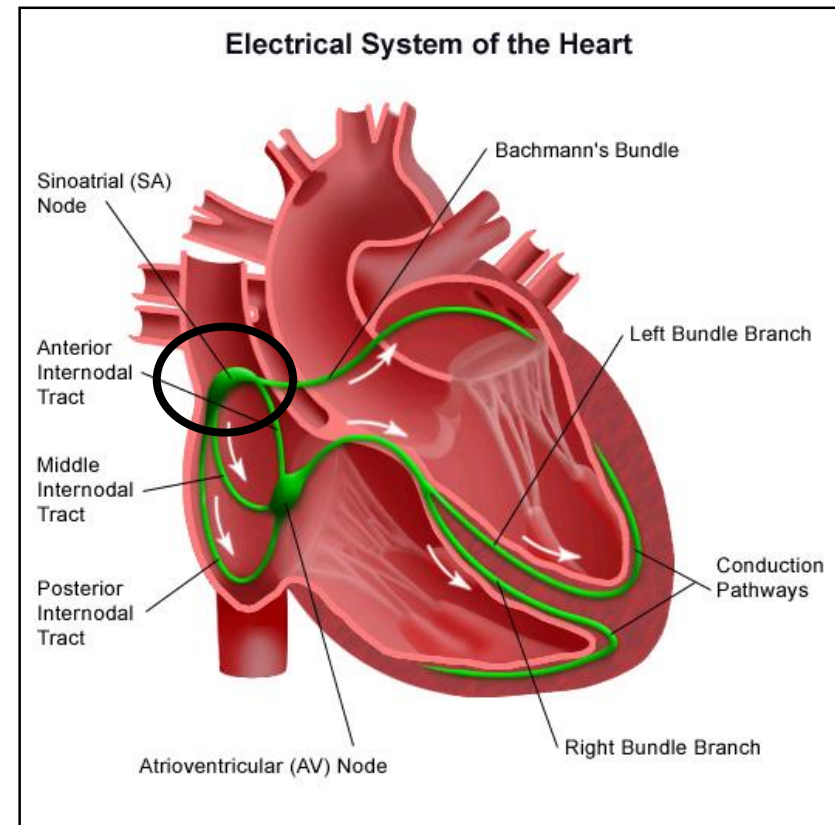
- Lateral wall of LV
- LA
- SA (50 %)
- AV (10 %)
- Posterior wall (10 %)

- After blood has passed through capillaries returns through the coronary veins
- They lie next to the coronary arteries
- Most drain into the coronary sinus into the right atrium
 - Some in the RV drain directly into the RA

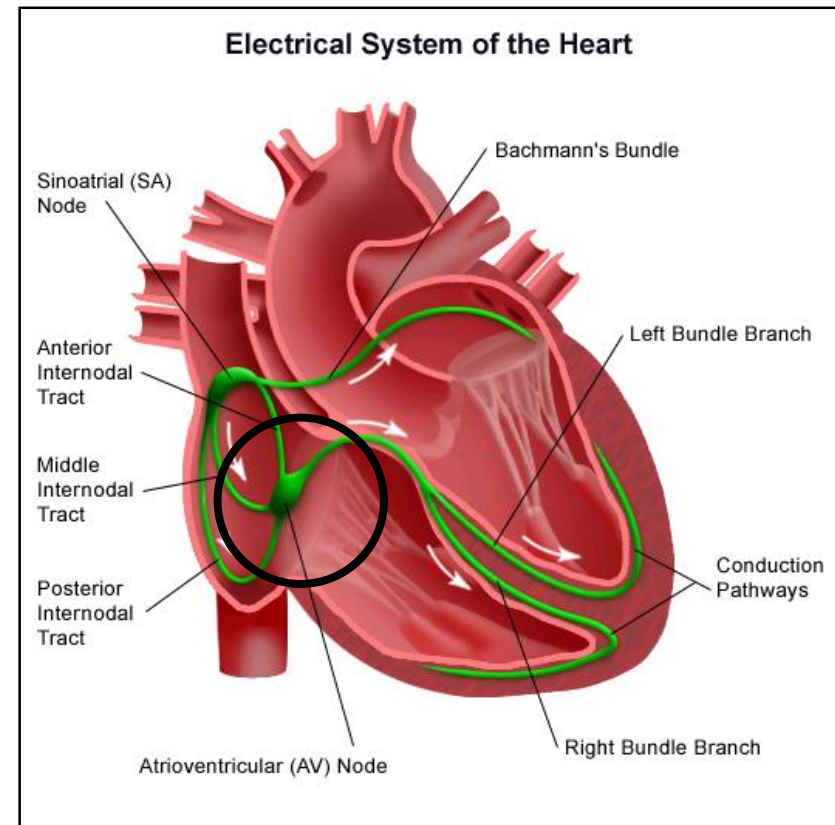


- Composed of
 - Sinoatrial Node
 - Atrioventricular node
 - Atrioventricular bundle
 - Purkinje fibers
- Specialized cardiac cells
 - Differ in function where they conduct as well as of conduct for contraction

- Consists of hundreds of cells near the opening of the Superior VC
- Intrinsic rate of 60 - 100 bpm
- Establishes basic rhythm, known as the pacemaker
- Impulses rapidly transfer to the atrium and cause them to contract and to the AV Node

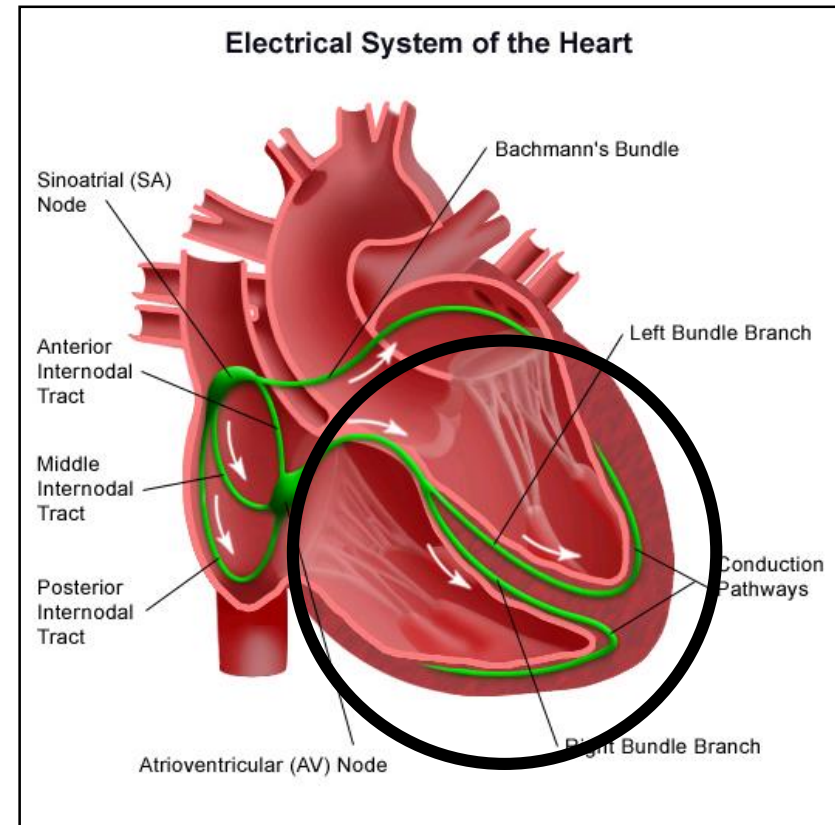


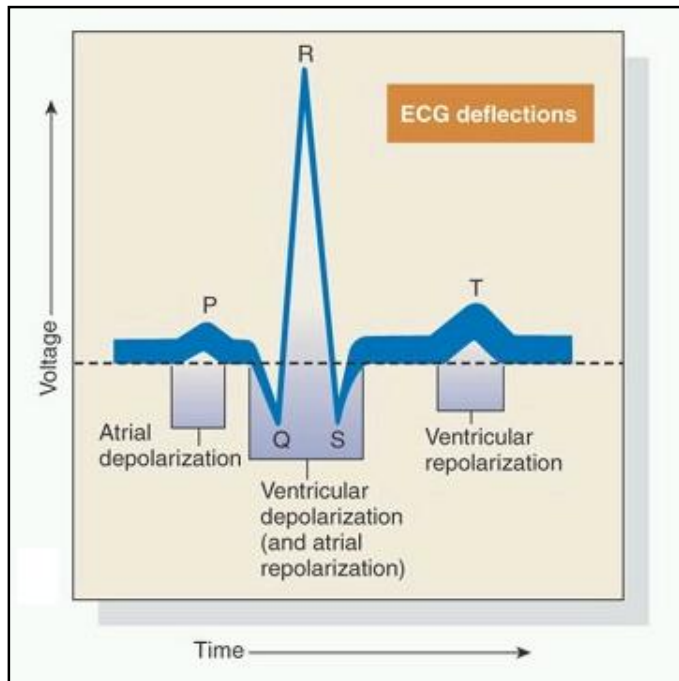
- Also known as the node of Tawara
- Located on the floor of the Right Atrium along the Interatrial septum
- Intrinsic value of 40 - 60 bpm
- Conducts impulse slower so gives a slight delay which allows for the atria to finish contracting



AV Bundle and Purkinje Fibers

- A bundle of specialized cardiac fibers extending from the AV Node
- Extends by two branches down either side of the Interventricular septum
- Impulse moves rapidly through the AV Bundle to the Right and Left Bundle Branches
- The Bundle Branches extend along the walls of the ventricles and papillary muscles
- Branch off to form the conducting myofibers (Purkinje Fibers)



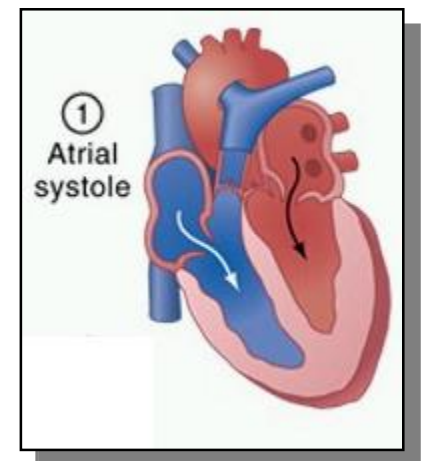


- A graphical representation of the heart's electrical activity
 - P Wave
 - Represents atrial depolarization
 - Caused by impulse from SA node to both atria
 - First to depolarize is first to repolarize
 - QRS Complex
 - Ventricular depolarization
 - Interventricular septum and Purkinje fibers
 - Atrial repolarization
 - T Wave
 - Ventricular repolarization
 - First to depolarize is last to repolarize
 - U Wave
 - Purkinje fiber repolarization in the papillary muscles

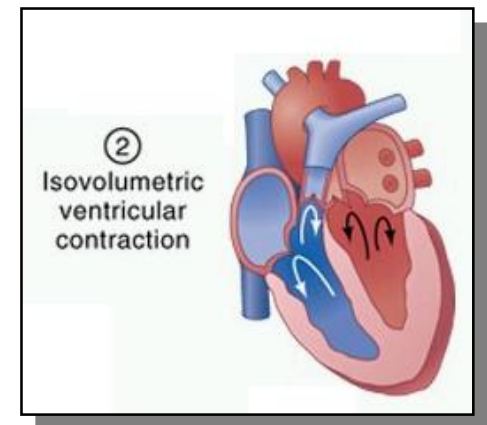
- Sympathetic
 - Contained in the Middle, Superior and Inferior Cardiac Nerves
- Parasympathetic
 - Vagus nerve
- Combine to form cardiac plexus at the arch of the aorta
- Extend from the plexus accompany coronary arteries to enter the heart
- Terminate in the
 - SA node
 - AV Node
 - Atrial myocardium

- A complete pumping cycle (heartbeat)
- Combination of systolic and diastolic phases (0.8 seconds)
- The five steps of a full cycle
 - Atrial Systole
 - Isovolumetric Ventricular Contraction
 - Ejection
 - Isovolumetric Ventricular Relaxation
 - Passive Ventricular Filing

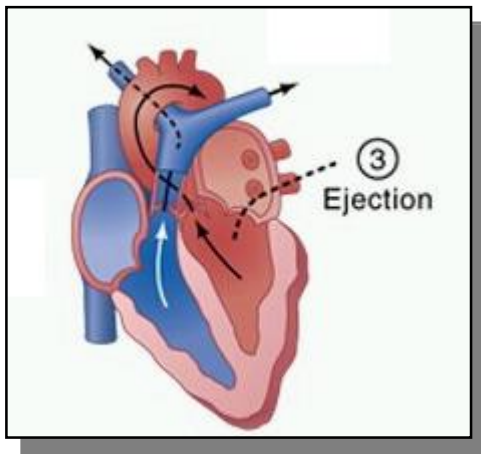
- AV valves are open
- Ventricles are relaxed
- Depolarization of atrial myocardium completes the emptying of the atria (atrial kick – accounts for 20% of blood volume)
 - Atrial systole (0.1 seconds)
- SL valves are closed
- Coincides with the P wave



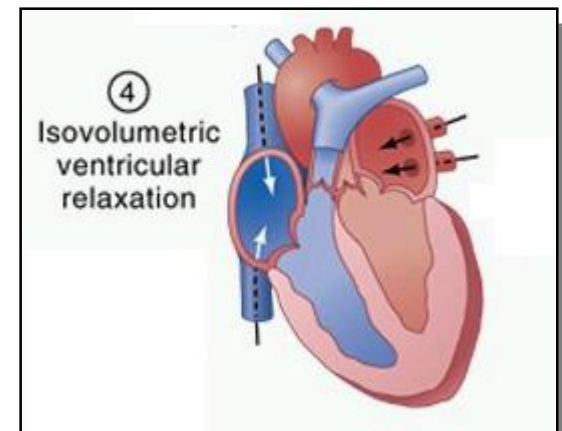
- AV Valves close
- Period between ventricular systole and the opening of the SL valves
- Volume remains constant as the pressure increases
 - Increase is from contraction of ventricular myocardium
- Coincides with the R wave
- Appearance of the first heart beat sound



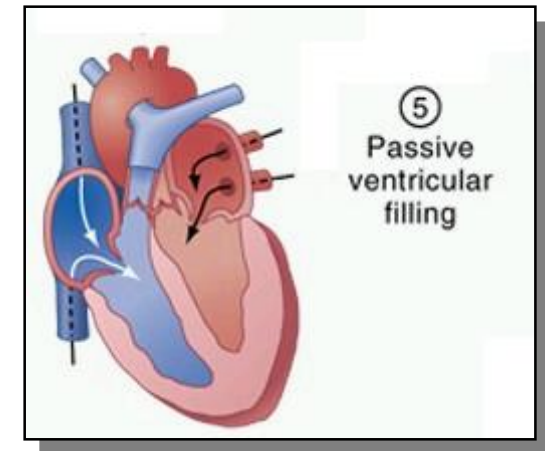
- SL valves open once the interventricular pressure exceeds the pulmonary artery and aorta pressures
 - Rapid ejection
 - Initial short phase
 - Marked by increase in pressures and an increase in aortic blood flow
 - Reduced ejection
 - Longer phase
 - Marked by decrease in ventricular emptying
 - Residual volume
 - Quantity of blood remaining in the ventricle at the end of the ejection phase

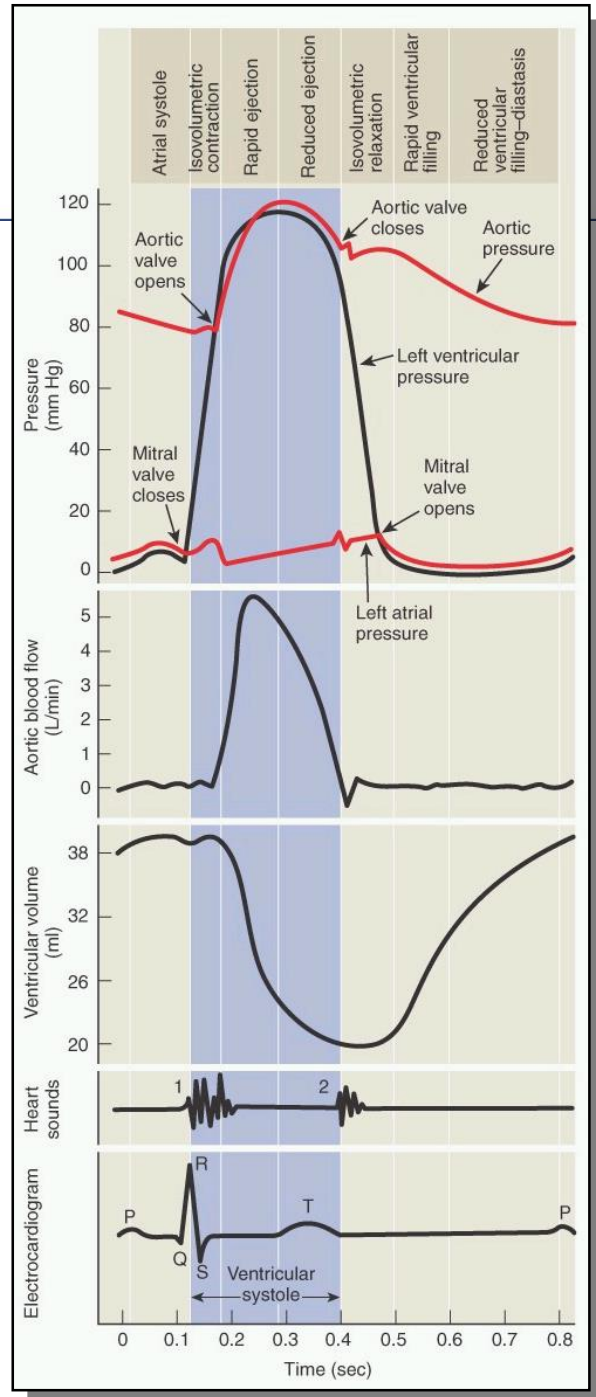
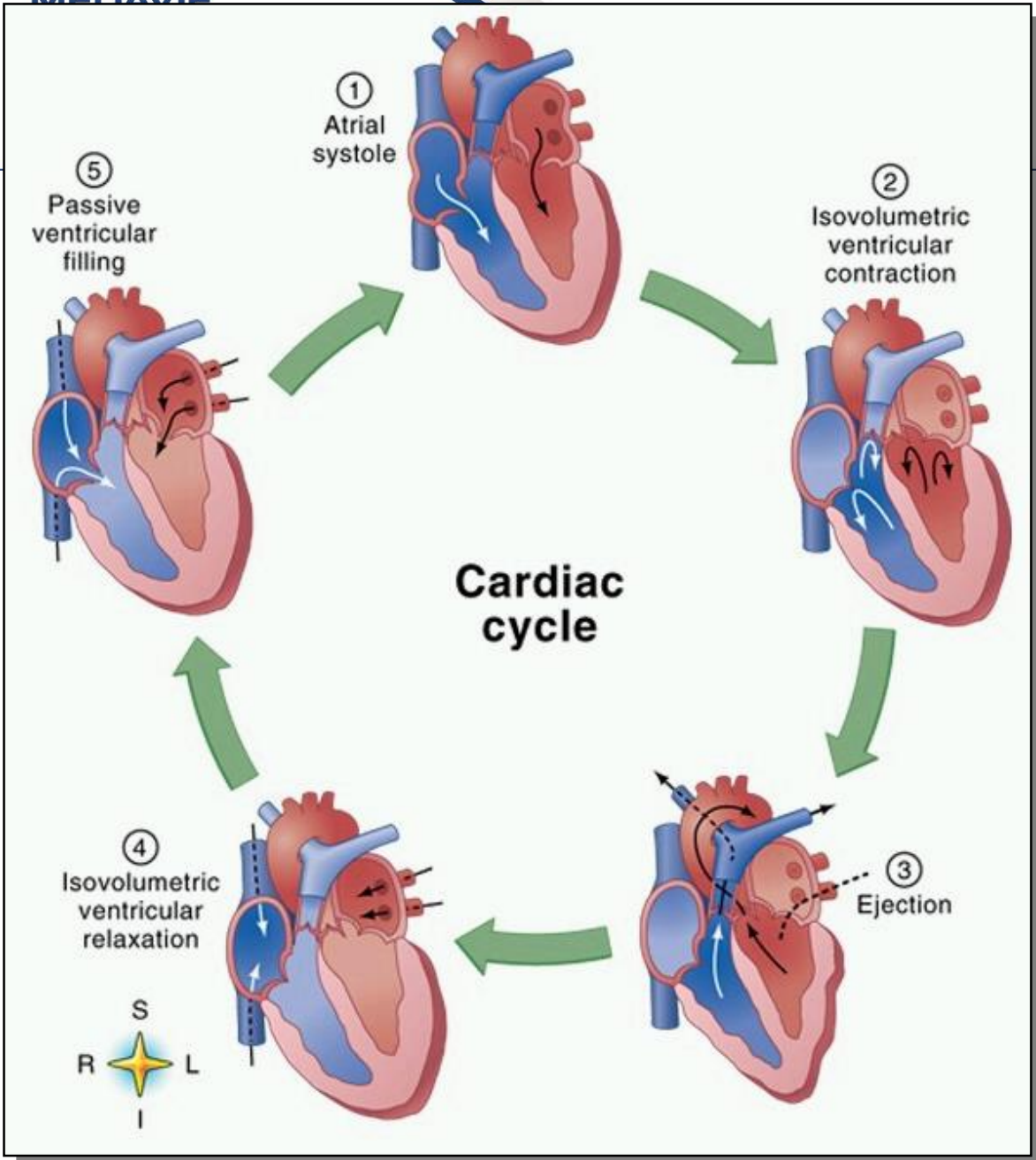


- Atria relax and begin refilling (atrial diastole)
- Ventricular diastole begins in this phase
- Identified by the closure of the SL valves and opening of the AV valves
 - Note pressure in the atria must exceed the ventricles for the valves to open
- Interventricular pressure decreases while volume stays the same
- Second Heart sound heard
- Atrial diastole is 0.7 seconds
- Ventricular systole is 0.3 seconds



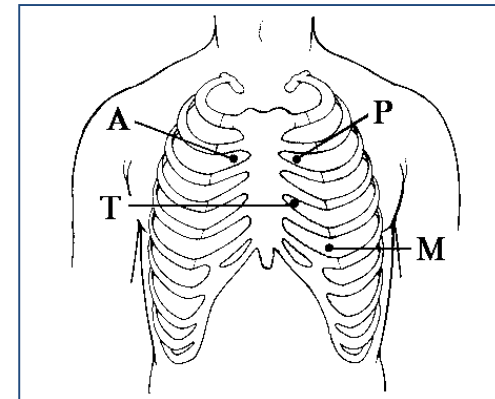
- Atria have been filling
- Interatrial volume and pressure have exceeded interventricular pressure
- Forces AV valves open
- Relaxation of the ventricles helps open AV valves with the help of papillary muscles and chordae tendineae
- Initial abrupt filling of the ventricles (0.1 seconds)
- Followed by a continuous flow (diastasis)
 - 0.2 seconds
 - Marked by an increase in ventricular volume and pressure
- Total ventricular diastole is 0.5 seconds



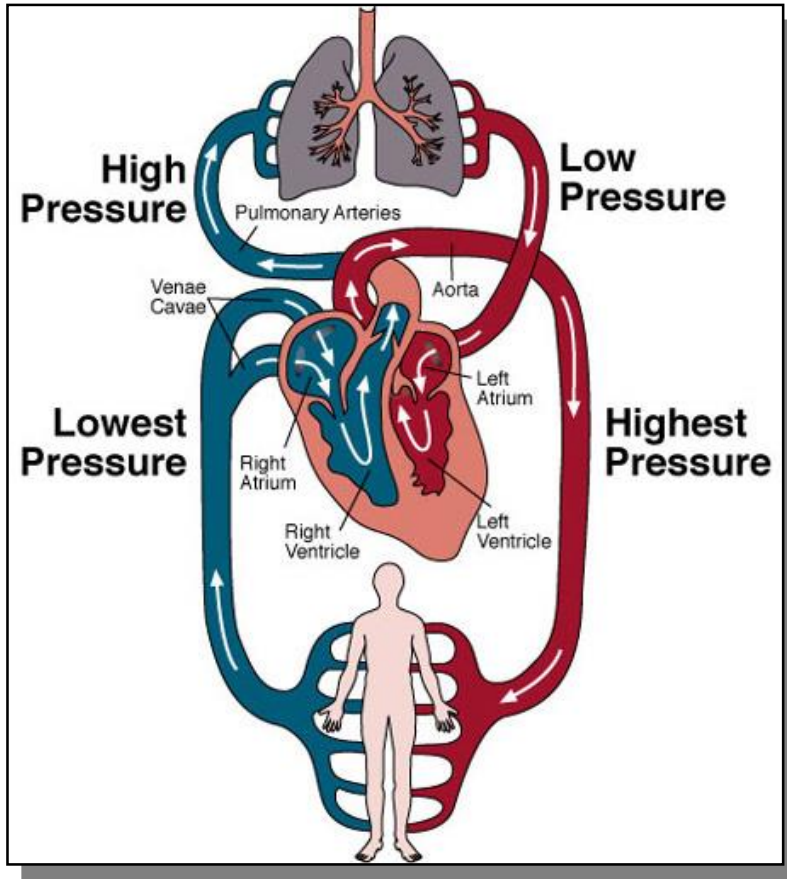


- Sounds made during the cardiac cycle
- Usually described as “lubb-dupp”
- First (S1)
 - Caused by contraction of the ventricles and closure of the AV valves
 - Longer and lower than second
- Second (S2)
 - Caused by closure of the SL valves
 - Shorter and sharper than the first

- Abnormalities in heart sounds may indicate problems with the functioning of the valves (difficult to hear if HR > 100)
 - S3 (ventricular gallop)
 - Caused by sudden tensing of ventricular wall
 - Low in volume and frequency
 - Normal in children, in adults may indicate CHF
 - S4 (atrial gallop)
 - Occurs during the second phase of ventricular filling: when the atriums contract just before S1.
 - Is thought to be caused by the vibration of valves, supporting structures, and the ventricular walls
 - An abnormal S4 is heard in people with conditions that increase resistance to ventricular filling, such as a weak left ventricle.
- For auscultation use landmarks in picture (A-Aortic valve, P-Pulmonic valve, T-Tricuspid, M-Mitral) in the supine position



Principles of circulation



- Fluid must move from an area of high pressure to an area of low pressure (down the pressure gradient)
 - Fluid will not move if the pressures are equal
 - Fluid moves from the left ventricle to the right atrium due to the blood pressure gradient

Mean Arterial Pressure

$$MAP = \frac{(2 \times DBP) + SBP}{3}$$

$$= \frac{(2 \times 80) + 120}{3}$$

$$= 93.3$$

$$MAP = DBP + \frac{\text{Pulse Pressure}}{3}$$

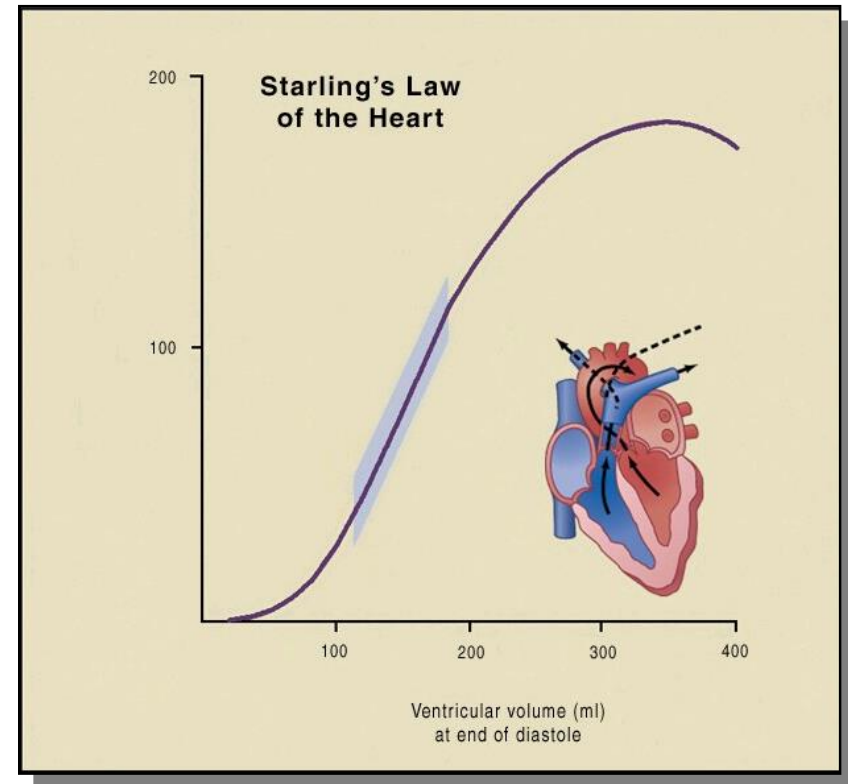
$$= 80 + \frac{(120 - 80)}{3}$$

$$= 93.3$$

- The amount of systolic discharge (ml/beat)
- Factors that affect SV
 - Mechanical (Starling's law of the Heart)
 - Neural
 - Chemical (inotropic effects of dopamine and epinephrine)

Starling's Law of the Heart

- Pertains to the length of the myocardial fibers at the beginning of the ventricular contraction
- The longer the stretch the stronger their contraction
- Related to the amount of blood in the ventricles at the end of the ventricular diastolic phase (LVEDV)
- Note:
 - Too much blood may extend the fibers past their critical point and cause them to lose their elasticity



- The rate at which the heart beats (b/min)
- Influential Factors:
 - Ratio of sympathetic and parasympathetic impulse per minute
 - Parasympathetic
 - Vagus nerve
 - Inhibitory by releasing acetylcholine
 - Sympathetic
 - Cardiac nerve
 - Excitatory by releasing norepinephrine

- Cardiac Pressoreflexes:
 - Baroreceptors in the carotid arteries and aorta sense changes in pressure
 - Carotid Sinus Reflex
 - Found at the base of the internal carotid
 - Baroreceptors attach to Herring's nerve (an extension of the glossopharyngeal (IX) cranial nerve) send signal to cardiac center in the medulla oblongata
 - If pressure is increased then vagus stimulation occurs slowing the HR down
 - Aortic Reflex
 - Found in the aortic arch
 - Through the aortic nerve into the vagus nerve (X) to the cardiac center
 - An increase in pressure will again stimulate a drop in HR

- Other reflexes
 - Emotions
 - Exercise
 - Hormones
 - Temperature
 - Pain
 - Visceral structure stimulation may result in such a slowing of HR that fainting may occur

- Carotid Sinus Reflex:
 - Baroreceptors in the carotid arteries and aorta sense changes in pressure
 - Send impulse to cardiac center in the medulla
 - Oppose changes in pressure by adjusting the heart rate

- The amount of blood returning to the heart during the diastolic phase
 - During diastole blood flows from the atria to the vents
 - Volume of each ventricle (EDV) is approximately 120 – 130 ml
 - Vents empty during systole so volume decreases (ESV) – approximately 50 – 60 ml
 - Therefore
 - $PL = EDV - ESV = 120 \text{ ml} - 50 \text{ ml} = 70 \text{ ml}$

- The amount of systolic discharge per minute (ml/min)

$$CO = HR \times SV$$

$$= 72 \frac{b}{min} \times 70 \frac{ml}{b}$$

$$= 5040 \frac{ml}{min}$$

- $BP = CO \times PVR$ (Peripheral Vascular Resistance)
- PVR
 - The resistance of blood flow by the force of friction between the blood and walls of the vessels
 - Viscosity of the blood
 - Changes in RBC volume or proteins
 - Diameter of the arterioles (over $\frac{1}{2}$)
 - Decrease in diameter will limit the flow of blood and in turn leave larger amounts of blood in the arteries thus increasing the PVR

- Vasomotor Control Mechanism
 - Changes in blood distribution and/or pressure may stimulate the vasomotor center
 - When stimulated it sends sympathetic impulses to the muscles surrounding the vessels (venules, arterioles and the blood reservoir) to constrict

- Vasomotor Pressoreflexes

- Increase

- stimulates Baroreceptors (carotid and aortic)
 - Stimulates the cardiac center
 - Results in parasympathetic stimulation of the heart and inhibition of the vasoconstrictor center
 - ↓ HR and venous pooling

- Decrease

- Baroreceptors stimulate cardiac center
 - Sympathetic response to the vasoconstrictor center

- Vasomotor Chemoreflexes
 - Found in the aorta and carotid bodies
 - Sensitive to hypercarbia
 - Less sensitive to hypoxia
 - Decreased arterial pH
 - Stimulation causes the vasoconstrictor center to be activated

- Medullary Ischemic Reflex
 - A powerful control mechanism of the blood vessels when cerebral blood flow drops
 - Causes ischemia to the medulla resulting in hypercapnia
 - This stimulates the vasoconstrictor center
 - If the oxygen supply decreases to a very low point this mechanism can not be stimulated

- Vasomotor Control by Higher Brain Centers
 - Cerebral cortex and hypothalamus are capable of stimulating the vasomotor center
 - Seen with fear, anger and other emotions

- Result of PVR
- \uparrow PVR = \downarrow SV
 - Due to \uparrow aortic pressure and the ventricles now must overcome this pressure first
- \downarrow PVR = \uparrow SV
 - If sufficient enough volume is present

- Chronotropy
 - Refers to heart rate
- Inotropy
 - Refers to contractile strength
- Dromotropy
 - Refers to rate of nerve impulse conduction

- The amount of blood returned to the heart
- Affect by
 - Venous pumps
 - Total blood volume

