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Research Paper

Article on Vascular system Anatomy of heart for Medicine

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The heart which is a cardiac organ that functions as a cone-shaped, hollow, muscular pump. An average human heart undergoes approximately 2.5 billion contractions throughout its lifespan. • The heart's left side propels blood through approximately 120,000 kilometers of blood vessels, a distance that is tantamount to circumnavigating the equator of Earth's approximately three times. • The heart's RV (right ventricle) propels blood by pulmonary circulation, facilitating the uptake of oxygen and the removal of carbon dioxide. The heart circulates over 14,000L of blood per day, or approximately 5 million L/yr.

Heart Dimensions •

The heart is a compact organ, measuring approximately 12cm (5in.) in length, 9cm (3.5in.) in width at its widest point, and 6cm (2.5in.) in thickness. On average, adult females have a heart mass of 250 g, while adult males have a heart mass of 300 g. • The heart which has been positioned on the diaphragm, in close proximity to midline of thorax cavity.

The mediastinum is the space among sternum & spinal column, extending from the 1st rib to diaphragm. It is located between the lungs and contains the heart.

Heart Relations

Superiorly – the SVC (superior vena cava), aorta, P-vein, and P-artery.

- **Inferiorly** – the diaphragm
- **Anteriorly –** the intercostal muscles as well as ribs.
- **Posteriorly** – the trachea, esophagus, descending aorta, IVC (inferior vena cava), left and right bronchus, and thoracic vertebrae
- **Laterally** – the lungs

The acute apex is created by the left ventricle (LV) apex and is situated at the diaphragm. It is oriented in an anterior, inferior, and leftward direction.

- The heart's posterior surface serves as its base. It is comprised of the heart's atria.

Surfaces

Under the sternum, the ribs cover the sternocostal or anterior body surface. The front of the thoracic wall protects the heart and lungs. Protecting and supporting the thoracic cavity's organs, the sternocostal surface is vital.

- The diaphragmatic or inferior surface of the heart is the area situated at heart apex & right border.
- The pulmonary or left surface is located in the left lung's cardiac notch.

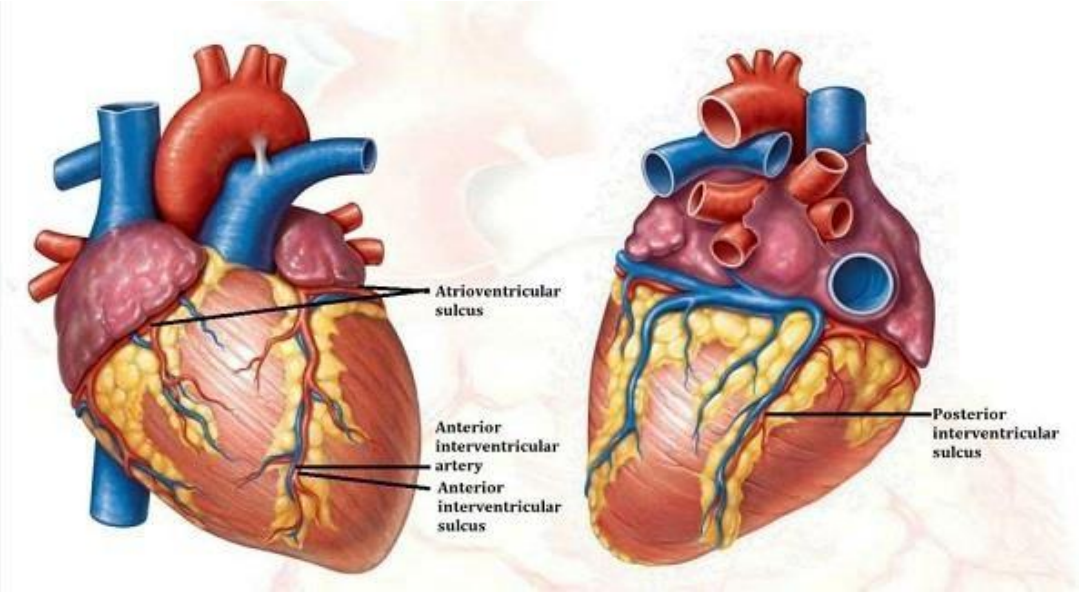
Boarders

The right border is delineated by the right atrium (RA) and is oriented towards right lung. It's from bottom to base.

- The lower boundary is comprised of the RV and partially the LV.
- Left ventricle and left auricle from the left border (pulmonary border). From base to apex, it faces the

left lung.

- Both atria form the superior border.



Sulci of Heart

The coronary sulcus is a furrow located on the heart's external surface that demarcates the boundary "between the atria along with ventricles.

1. Atrioventricular sulcus
2. Anterior interventricular sulcus
3. Posterior interventricular sulcu

Atrioventricular sulcus: The structure known as the atrioventricular septum serves to divide the atria from the ventricles. It involves the left coronary artery(LCA), circumflex artery, right coronary artery(RCA), and coronary sinus.

- **Anterior interventricular sulcus :** The structure lies at anterior surface between the LV & RV. It contains the great cardiac vein and left anterior descending artery and indicates interventricular septum.
- **Posterior interventricular sulcus**: The structure lies at posterior surface between the LV &RV. It includes the posterior interventricular artery along with middle cardiac vein".

Pericardial Sinuses

Two pericardial sinuses are formed by the reflection lines between the visceral as well as parietal pericardium.

a. **The transverse pericardial sinus** The structure is positioned in front of the SVC and behind the pulmonary trunk and ascending aorta.

b. **The oblique pericardial sinus** The structure is located behind the heart within the pericardial sac.

AURICLE

Each atrium anterior surface is characterized by a convoluted and pouch-like structure known as an auricle. The presence of each auricle slightly enhances the atrium's capacity, allowing it to accommodate a larger volume of blood.

Heart Coverings Pericardium

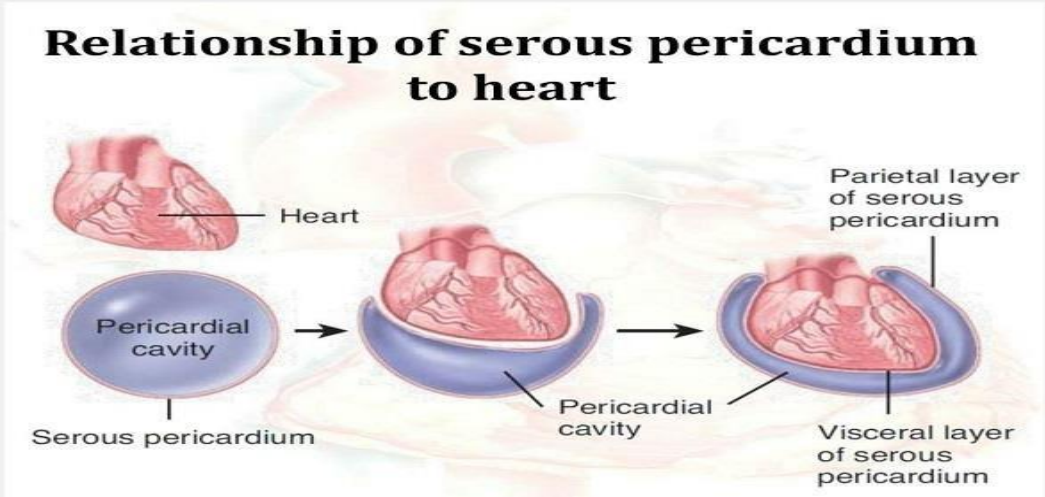
- The heart is contained within a protective structure known as the pericardium, which consists of two layers.
- It comprised of 2 primary parts:

1. The fibrous pericardium
2. The serous pericardium

- **The fibrous pericardium** Consists of resilient, inflexible, compact irregular connective tissue. It serves to

1. Avoid heart overstretching.
2. Heart protection
3. Mediastinum-anchored heart

Relationship between heart and serous pericardium



The "serous pericardium which is a thin membrane which envelops the heart, consisting of two layers.

- The outer parietal layer is tightly joined to the fibrous pericardium.
- The inner visceral layer, known as the epicardium, facilitates the heart wall layers strong adherence to the surface of the heart.

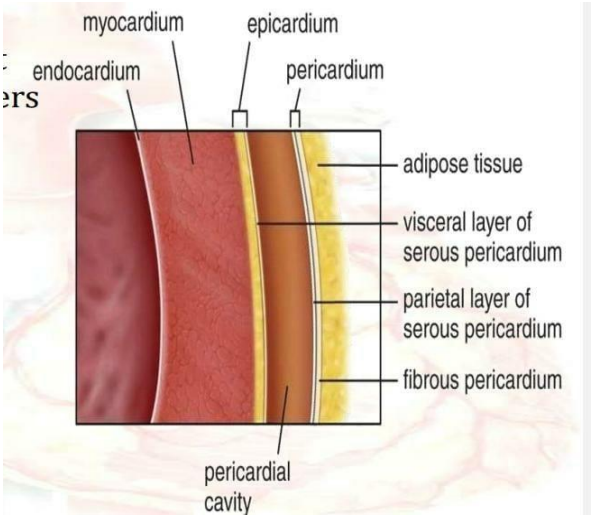
The layers of the heart wall and pericardial layers.

The" pericardial fluid, found among the parietal as well as visceral layers, serves to lubricate and minimize friction during the heart's contractions. This fluid resides in the pericardial cavity, that is the space among the two layers.

Heart Wall Layers

The heart wall which is comprised of 3 "layers.

- The epicardium (external layer)
- The myocardium (middle layer)
- The endocardium (inner layer)



Epicardium

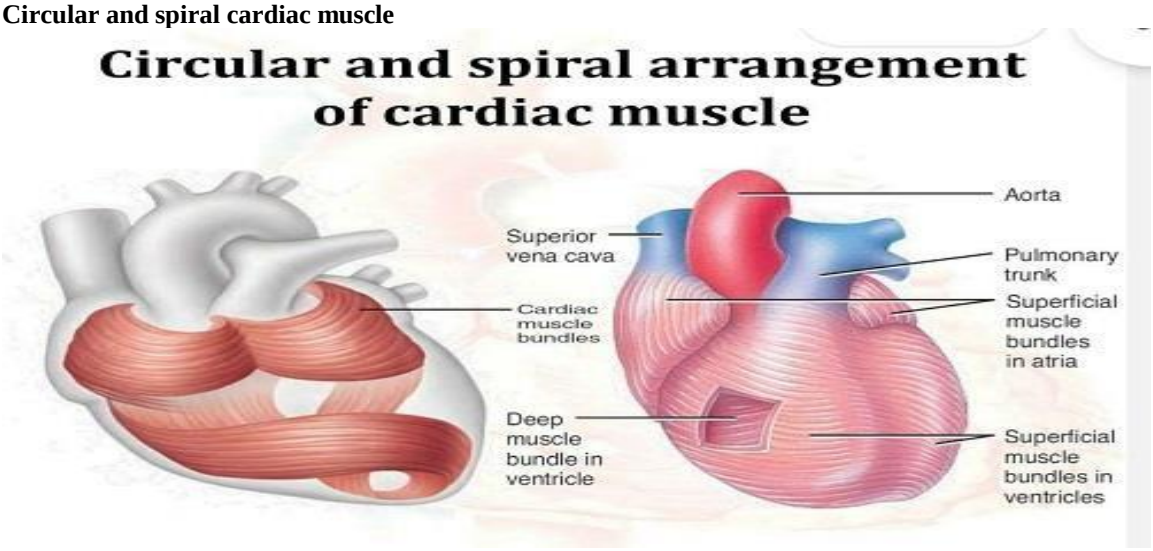
- The heart wall outer layer is a thin, transparent membrane made up of mesothelium, which is a type of membrane consisting of simple squamous cells.
- The epicardium is composed of lymphatics, blood vessels", and vessels which provide nourishment to the myocardium.

Myocardium

- Heart pumping is done by the myocardium, cardiac muscle tissue. Muscle fibers are surrounded by endomysium as well as perimysium sheaths.

- The cardiac muscle fibers are arranged in helical bundles, which contribute to the powerful contractile heart's movements.

Circular and spiral cardiac muscle

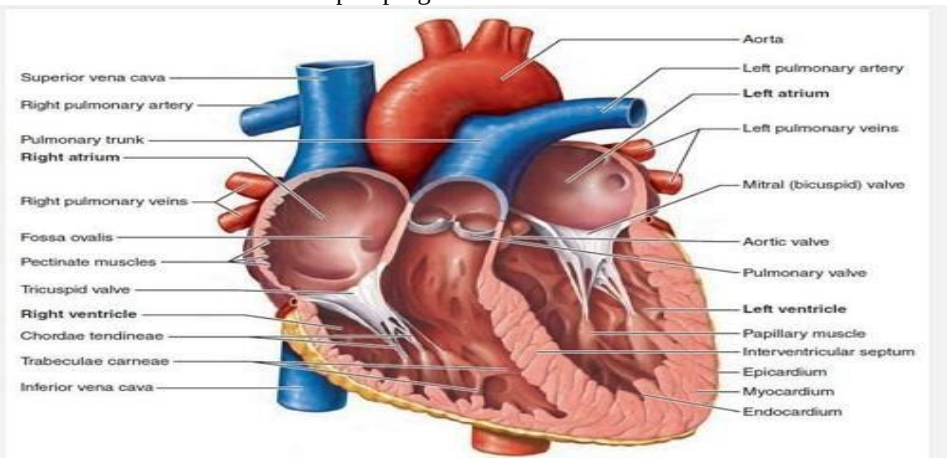


Endocardium

- The endocardium is endothelium's smooth layer, which is a type of flat epithelium, that lies on top of a connective tissue's thin layer.
- The heart chambers inner lining is comprised of a layer that also covers the valves fibrous structure.
- The endocardium is seamlessly connected to blood vessels endothelial linings that exit and enter the heart.

Heart Chambers

The heart consists of 4 chambers. The atria serve as superior chambers to receive blood, while the ventricles function as inferior chambers for the blood pumping.

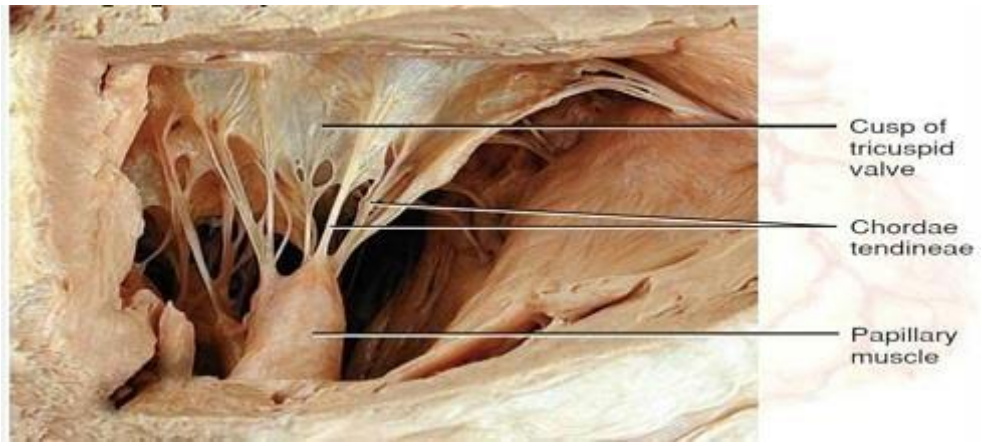


Right Atrium

Three veins—superior, inferior, and coronary—feed the right atrium, the heart's right boundary. The right atrium is 2–3 mm thick.

- Pectinate muscles give the anterior wall a rough texture, while the posterior wall which is smooth.
- The interatrial septum that divides the right and left atriums(LA). The fossa ovalis is a notable characteristic of this septum, which is a depressed area shaped like an oval.

. • The tricuspid valve, consisting of 3 leaflets, facilitates the movement of blood through RA to the RV. "Chordae tendineae connect the tricuspid valve cusps to cone-shaped papillary muscles".



Right Ventricle

- The right ventricle has an average thickness of around 4–5mm (0.16–0.2 in.) and comprises the majority of the heart's anterior surface.
- The heart's RV consists trabeculae carneae, which are bundles of cardiac muscle fibers arranged in ridges. These structures aid in the heart conduction.
- The interventricular septum serves as a partition among the RV & LV.
- The pulmonary valve directs the blood flow through RV into the pulmonary trunk, a significant artery that

"divides into the right & left P-arteries.

Left Atrium

- Both the" LA and the RA have comparable thicknesses, however the LA constitutes the larger portion of the heart's base.
- The heart receives oxygenated blood from 4 P-veins. The anterior as well as posterior walls of the LA are smooth due to the absence of pectinate muscles, which are only present in the auricle.
- The blood flow through the LA to LV occurs via the bicuspid (mitral) valve. It is alternatively referred to as "the left atrioventricular valve.

Left ventricle.

This forms the heart apex, is the heart's thickest chamber, with an average thickness of 10-15 mm (0.4-0.6 in.). Similar to the RV, the LV also consists of trabeculae carneae as well as chordae tendineae, which" serve to anchor "the cusps of the bicuspid valve to the papillary muscles.

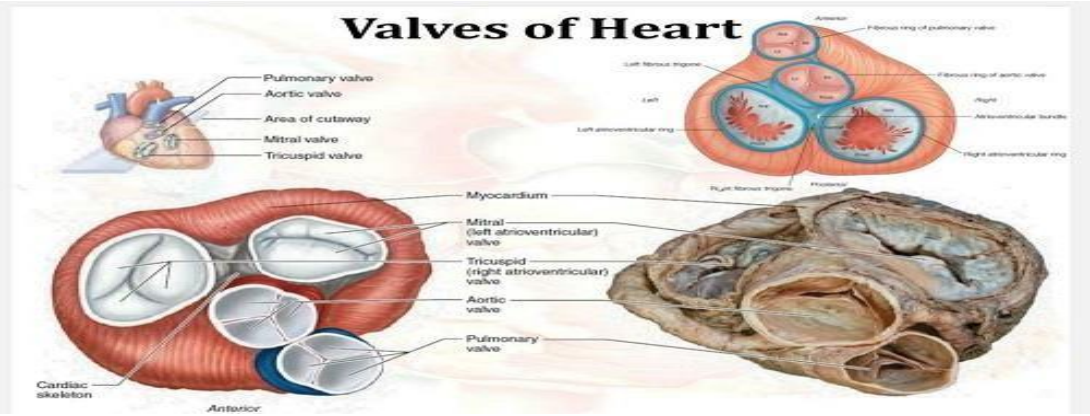
The ascending aorta receives blood from the LV via the aortic semilunar valve. Blood then enters the ascending aorta-derived coronary arteries, that supply blood to wall of heart.

The remaining blood enters the descending aorta, which includes the thoracic and abdominal aortas. The descending aorta & aortic arch" branches supply blood to body.

Comparison of right and left atrium

	Right atrium		left atrium
1	Receives venous blood from body.	1	Receives oxygenated blood from Lung.
2	Pushes blood to Rt ventricle through tricuspid valve.	2	Pushes blood to Lt ventricle through bicuspid valve.
3	Forms Rt boarder, parts of sternocoastal and small part of base of the heart	3	Forms major part of the heart base

Comparison of right and left ventricle



	Right Ventricle		left Right Ventricle
1	Thin	**1**	Thicker
2	Pushes blood only to the lung	**2**	Pushes blood to entire body except lung
3	Contains three papillary muscles	**3**	Contains two papillary muscles
4	Cavity is crescentic	**4**	Cavity is circular
5	Contains deoxygenated blood	**5**	Contains oxygenated blood

The Tricuspid Valve

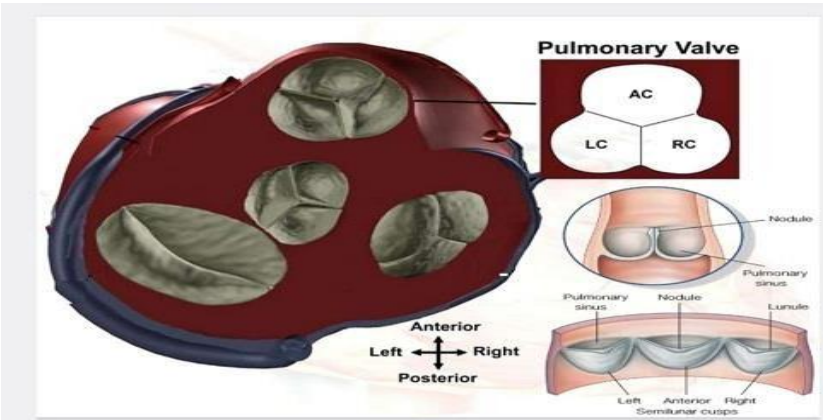
Each of the 3 cusps that make up the tricuspid valve are located in the anterior, septal, and inferior (posterior) positions. In addition to the presence of connective tissue, the folding of the endocardium is responsible for the formation of these cusps. At their bases, the cusps of the heart valves are connected to the heart skeleton fibrous ring. On the other hand, the heart valves free edges which have been attached to the chordae tendineae, which in turn connect them to papillary muscles.

The Mitral Valve

Two cusps make up the mitral valve: "anterior & posterior. Its structure resembles the tricuspid valve. The larger anterior cusp divides the atrioventricular as well as aortic orifices. The chordae tendineae connect the cusps to the papillary muscles like the tricuspid valve".

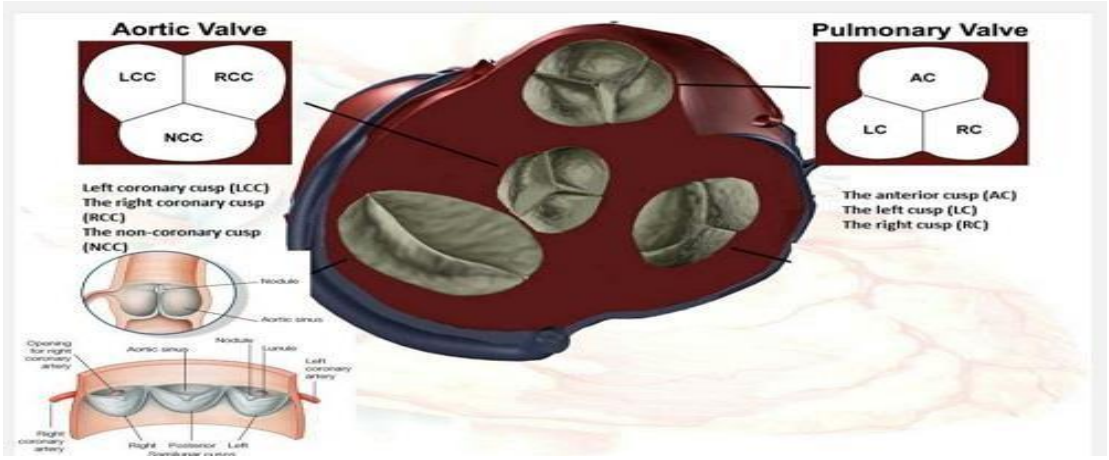
The Pulmonary Valve

- Three crescent-shaped cusps have been created by endocardium along with the connective tissue folds. Lower cusp edges and sides are arterially connected.
- The pulmonary valve is composed of 3 cusps: the left cusp (LC), the anterior cusp (AC), and the right cusp (RC).
- These valves lack any attachment to chordae tendineae or papillary muscles.



The Aortic Valve

- One anterior valve is on the right and two posterior valves are on the left & posterior sides.
- The aortic valve is composed of 3 cusps: RCC, the LCC, and the NCC.
- The RCA arises by anterior aortic sinus, while the LCA originates "from the left posterior sinus.



Blood supply to the heart

The" heart's tissues are "supplied with blood by the right & left coronary arteries, which are the first branches of the aorta. The LCA divides into anterior interventricular artery as well as circumflex artery. The anterior interventricular artery delivers blood to the septum & anterior walls of the both ventricles, while the circumflex artery supplies the posterior walls of the LA and LV."

The "right marginal artery supplies blood to lateral right myocardium from the RCA, which runs toward the heart's right side. The anterior & posterior interventricular arteries anastomose to supply blood to the ventricles' posterior walls.

Coronary Veins

Venous blood from the heart is collected by a network of cardiac veins. These veins converge to create the coronary sinus, a large dilated vessel that serves as the main drainage route for deoxygenated blood from the myocardium. The coronary sinus then empties this blood directly into the right atrium, ensuring that deoxygenated blood is returned to the heart for reoxygenation in the lungs.

- The main branches transporting blood into coronary sinus are as follows:

1. The left, right, and left atrial ventricles, as well as other heart regions supplied by the LCA, are drained by the great cardiac vein, which is situated in the anterior interventricular sulcus.
2. The LV & RV, supplied by the posterior interventricular branch of the right coronary artery (RCA), are drained by the middle cardiac vein, located in the posterior interventricular sulcus.
3. The coronary sulcus' small cardiac vein drains the RA and RV.
4. The anterior cardiac veins which had been drain blood from the RV directly into the RA. These veins bypass the coronary sinus, unlike most other veins of the heart

Nerve supply to the heart

- The cardiac nerves, a network of autonomic fibers located where the trachea divides into the left and right bronchi, play a crucial role in regulating heart function. They transmit signals from the autonomic nervous system to control heart rate, contraction strength, and overall cardiovascular activity.• Their primary role is to provide nerve supply to the heart's electrical conducting system, as well as to the atrial & ventricular myocardium and the coronary vasculature".
- The main brain region that controls sympathetic as well as parasympathetic signals to the heart as well as blood vessels is the medulla.
- The hypothalamus and greater brain regions control medullary center activity, regulating cardiovascular responses to emotions, exercise, and "thermal stress.

The Sympathetic Nerve actions

- The sympathetic nerve fibers originate from the intermediolateral cell column of the thoracic spinal cord segments T1 to T4. These fibers then converge into the sympathetic trunk, a major pathway of the autonomic nervous system. This network allows for the coordination and distribution of sympathetic signals

throughout the body, playing a essential role in the body's fight-or-flight response and the regulation of various physiological processes.

- In cervical and thoracic sympathetic ganglia, preganglionic fibers form synapses. The cardiac plexus receives postganglionic fibers from these ganglia.
- As the parasympathetic system which slows the rate of heart, the sympathetic nervous system speeds up cardiac contractions and constricts coronary vessels.

Parasympathetic Nerve Actions

- The vagus nerve (CN X) supplies preganglionic parasympathetic fibers. • They lower rate of the heart, weaken cardiac contractions, and expand coronary resistance vessels during innervation.
- The majority of the vagal effects are confined to the sinoatrial node vicinity.

Cardiac muscle fibers

- Transversely, cardiac muscle fibers" exhibit distinctive characteristics compared to other muscle types. They are generally shorter and exhibit a less circular shape, giving them a unique appearance. The fibers are arranged in a branching pattern that resembles a series of interlocking steps. This branching configuration allows for an intricate network of connections between individual fibers, facilitating the efficient transmission of electrical signals and mechanical forces throughout the heart.

Cardiac muscle fibers, also known as cardiomyocytes, are specialized cells responsible for the contraction of the heart. These fibers typically measure between 50 and 100 micrometers in length and possess a diameter of approximately 14 micrometers. Each fiber contains a single, centrally located nucleus, which is crucial for the regulation of cellular functions.

- Cardiac muscle fibers are intricately connected by specialized structures called intercalated discs. These discs are sarcolemma's irregular transverse thickenings, the cell membrane of the cardiac muscle cells. Intercalated discs play a essential role in maintaining the structural integrity of the cardiac muscle tissue by anchoring adjacent cells together. They also facilitate the efficient transmission of electrical impulses and mechanical forces across the heart, ensuring coordinated and synchronized contractions essential for effective cardiac function.
- Disks contain desmosomes, which maintain fiber cohesion, and gap junctions, which transmit muscle action potentials.
- Gap junctions facilitate the synchronized contraction of the entire myocardium of the atria or ventricles as a cohesive entity.
- Cardiac muscle fibers have similar actin and myosin organization, zones, bands, and Z discs to skeletal muscle fibers.

Applied Anatomy

X-ray (Radiography) - Chest

- Chest x-ray employs a minute amount of ionizing radiation to generate images of the interior of the chest.
- It assess heart, lungs, and chest wall to diagnose symptoms like chronic cough, difficulty breathing, chest discomfort, elevated body temperature, and physical trauma. It can also help diagnose and monitor emphysema, pneumonia, and cancer.

Coronary angiography

- It uses x-rays and a dye to visualize blood flow through the heart's arteries. The dye helps identify blood circulation obstructions.

References

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