

CARDIOVASCULAR SYSTEM

CIRCULATORY SYSTEM, HEART VESSEL SYSTEM

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CIRCULATORY SYSTEM

- Transport system
- Consists of liquid intermediates and cells
- Carries nutrients, hormones, antibodies and metabolites
- Circulation from center to periphery with pressure
- Lymph circulation is linked to blood circulation
- The cardiovascular system carries blood between tissue and heart
- The lymphatic system carries excess extracellular fluid through the lymphatic vessels to the heart
- Therefore, while the lymphatic system is one-way, the cardiovascular system is two-way

Cardiovascular system features

- Pump → Heart
- Circulation → Heart and Vessels
- Pressure → Systole and Diastole
- Viscosity → Blood Cells

Once a heart beats, it sends 80 ml of blood to the pulmonary artery and aorta

6 liters of blood are excreted throughout the heart per minute.

- **CVC consists of the heart, blood vessels and lymphatic vessels**
- **There are 2 types of circulation in the body**
 - **Pulmonary circulation**
 - **Systemic circulation**

HEART

LEARNING OBJECTIVES



- Layers of the heart
- Histological properties of layers
- Functions of the heart muscle cells
- Histological features of the impulse forming and transmitting system
- Histological features of the heart valves and fibrous skeleton



HEART

It is a muscular organ

It contains four chambers :

- Two atria**
- Two ventricles**

Systemic blood

VCS ve VCI

right atrium

↓ **right atrioventricular
(tricuspid) valve**

right ventricle

↓ **semilunar (pulmonary) valves**

pulmonary turuncus and right pulmonary artery /
left pulmonary vein (**Pulmoner circulation**)

↓
left atrium

↓ **left atrioventricular
(Bicuspid / mitral) valve**

left ventricle

↓ **semilunar (aortic) valves**

Aorta

HEART HISTOLOGY

- It is a sac that pumps blood through rhythmic contractions.
- It consists of three layers:
 - * Endocardium
 - * Myocardium
 - * Epicardium

ENDOCARDIUM

From inside out;

1. **Endothelial layer;** A simple squamous epithelium
2. **Subendotelial connective tissue layer;** contains elastic and collagen fibers and few smooth muscle cells
3. **Musculoelastic layer;** consists of elastic fibers and smooth muscle bundles.
4. **Subendocardial layer;** is in the structure of loose connective tissue containing small blood vessels, nerves and Purkinje fibers.

MYOCARDIUM

**It is equivalent to T. Media and is the thickest of tunica
It consists mostly of cardiac muscle fibers.**

**Includes impulse-transmitting system and parts of the heart
skeleton.**

**Each muscle fiber is surrounded by an endomysium and
each fascicle surrounded by perimysium**

MYOCARDIUM

- It is the thickest layer of the heart Wall.
- It consists of heart muscle cells.
 1. **Contractile cardiocytes**, which contract to pump blood through the circulation.
 2. **Myoendocrine cardiocytes**, producing atrial natriuretic factor.
 3. **Nodal cardiocytes**, specialized to control the rhythmic contraction of the heart. These cells are located in sinoatrial node (SA) and atrioventricular node (AV).

CARDIOCYTES

*85-100 μm in length,
1.5 μm in diameter.

A single centrally located nucleus

Branched cylinders

(Atrium myocytes are smaller than ventricular myocytes.)

*Glycogen, lipofuscin, pigment granules are common in cytoplasm.

CARDIOCYTES

1- Contractile Cardiocytes:

- ✓ Cardiac (heart) muscles have striated, branched fibers.
- ✓ Contractile proteins are the same as skeletal muscle.

- ✓ Cytomembranes exhibit some differences:
 1. T tubules are found at the level of Z disk.
 2. Sarcoplasmic reticulum is not as extensive as that of skeletal muscle.
 3. Diads are typical in cardiocytes.
 4. Mitochondria are not abundant in cardiac muscle than in skeletal muscle.

Cardiac muscle cells are joined end - to - end by the intercalated discs (junctional complex of the two cell membranes of two adjacent cardiac muscle cells)

The intercalated disks provide direct electrical coupling between cells to coordinate contraction of the heart

The transvers component consist of:

1. **Desmosomes**, which mechanically link cardiac cells.
2. **Zonula adherens** contains α -actinin and vinculin .

Longitudinal component

1. **Gap junctions**; This structure provides ionic communications.

MYOCARDIUM

Atrial Cardiac Muscles

- The heart muscle is thin in the atria and thick in the ventricles.
- The muscles in the outer part of the atrium are transverse and oblique.
- Between the muscle cells are collagen and elastic fibers

According to the ventricular muscles;

Atrial muscles

- 1- They are smaller,**
- 2- They contain many secretion granules such as atrial natriuretic factor,**
- 3- It has fewer T tubule systems,**
- 4- There are many more gap junctions,**
- 5- Impulse transmission is fast**
- 6- They contract more rhythmically.**

2- Nodal cardiocytes:

- It controls the rhythmic contractions of the heart.

These cells are located in

the sinoatrial node, at the superior vena cava-right atrium junction;

the atrioventricular node, present under the endocardium of the interatrial and interventricular septa.

The action potential responsible for cardiac contraction is generated primarily from the sinoatrial node, located near the orifice of the superior vena cava. The impulse is transmitted across the atria and to the atrioventricular node, where it then depolarizes the ventricles via the bundle of His and associated Purkinje fibres.

- **SA and AV node cells are structurally similar.**
- **These cells are smaller and paler than the surrounding cardiac muscle cells.**
- **The cells are spread out within a mesh of connective tissue, containing nerves, blood vessels, collagen and fat.**

The bundle of His is characterized by longitudinal collagen partitioning histology, distinguishing it from the AV node

Purkinje fibres

- The Purkinje fibres are found in the sub-endocardium.
- They are larger than cardiac muscle cells, but have fewer myofibrils, lots of glycogen and mitochondria, and no T-tubules. These cells are connected together by desmosomes and gap junctions, but not by intercalated discs.
- They are specialised conducting fibres, which extend from the interventricular septum, to the papillary muscles, and up the lateral walls of the ventricles.

PERICARDIUM

- The pericardium is a double-walled sac enclosing the heart.
- Fibrous Layer (pericardium fibrosum)
- Serous Layer(pericardium serosum)
 - Parietal Layer (outer serous layer)
 - Visceral Layer (inner serous layer)(**epikardiyum**)
- The fibrous pericardium is strong fibrous sac which supports the delicate parietal layer of the serous pericardium with which it is firmly adherent.

SEROUS PERICARDIUM

- Enclosed within the fibrous pericardium, the serous pericardium is itself divided into two layers:
 - The outer parietal layer that lines the internal surface of the fibrous pericardium.
 - The internal visceral layer that forms the outer layer of the heart (also known as the epicardium).

Each layer is made up of a single sheet of epithelial cells, known as mesothelium.

Epikardiyum;

- The Epicardium (Visceral Pericardium) is a serous membrane covered externally by a single layer of mesothelial cells
- Beneath the mesothelium, there is a relatively thick layer of areolar or adipose tissue.
- The subepicardial layer lies between, and joins, the myocardium and the epicardium.
- The **subepicardial layer** contains the coronary blood vessels and nerves.

CARDIAC SKELETON

- It provides structural support for the heart.
- The fibrous rings are composed of dense irregular connective tissue.
- It creates areas of attachment to the heart muscles and valves.
- Skeleton of heart forms basis of electrical discontinuity between atria and ventricles.

A fibrous skeleton that consists of four fibrous rings surrounding the valve orifices, two fibrous trigones connecting the rings, and the membranous part of the interventricular and interatrial septa.

CARDIAC SKELETON

- Major elements;
 - **Anuli fibrozi** ; in the aorta, pulmonary artery bases and at the base of the openings of the atrioventricular valves,
 - **Trigonum fibrosum** ; The triangle between annuli fibrosa and ostium atrioventricularis
 - **Septum membranaceum** ; membranous parts of the septum between the atrium and ventricles

HEART VALVES

- The heart valves attach to the complex framework of dense irregular connective tissue that forms the fibrous rings and surrounds the orifices containing the valves.
- Valve cusps are normally avascular.
- In the AV valves, the ventricularis continues into the chordae tendineae, which are fibrous, thread-like cords also covered with endothelium.

Each valve is composed of three layers:

- **The fibrosa** forms the core of the valve and contains fibrous extensions from the dense irregular connective tissue of the skeletal rings of the heart.
- **The spongiosa** is loose connective tissue located on the atrial or blood vessel side of each valve.
- **The ventricularis** is immediately adjacent to the ventricular or atrial surface of each valve and is covered with endothelium.

VESSELS OF THE HEART

- The heart vessels occur anastomosis through the subepicardial layer.
- Coronary arteries are muscular type arteries.
- Lymph capillaries are located;
 - in the subendothelial layer in the endocardium,
 - around the muscle cells in the myocardium
 - in the epicardium.

NERVES OF THE HEART

- The parasympathetic and sympathetic system nerve fibers form neural network in the subepicardial layer.
- This neural network enters the myocardium and ends on muscle cells.
- **Motor end plates are not observed.**



Thank you

<http://www.histology.leeds.ac.uk/circulatory/heart.php>

https://en.wikipedia.org/wiki/Cardiac_muscle

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Human Anatomy, McKinley & O'Loughlin, Third edition