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ESSENTIALS OF THE CARDIOVASCULAR SYSTEM

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The cardiovascular system is a closed system filled of blood. This system consists of heart and blood vessels (arteries, arterioles, capillaries, venules and veins). Blood circulates continuously in this system by the pumping action of the heart. With the probable exception of the liver sinuses and the spleen, blood does not get into direct contact with the tissues, which are bathed in the interstitial fluid. Blood carries nutrient, waste products, hormones, gases etc from one part of the body to another hence, blood circulates without cease along the animal life. The exchange of materials carried by the blood and the interstitial fluid takes place by means of diffusion and filtration through the thin walled blood capillaries. Excess interstitial fluid is drained by the lymphatic vessels and returned back to the blood. The heart and most of the veins possess valves which permit the circulation of blood in one direction (the heart to arteries to capillaries to veins to the heart) and prevent regurgitation of the blood in the opposite direction. All the arteries carry oxygenated blood except the pulmonary while, all the veins carry deoxygenated blood except the pulmonary ones.

Physiological anatomy of the heart

1) The heart of mammals:

The heart is a cone shape, hollow muscular pump that forces the blood in the blood vessels. It is situated in the middle mediastinal space of the thoracic cavity. The heart is surrounded by a serous membrane called *peritoneum* which forms a complete closed sac. This **pericardial sac** protects the heart as well as it allows the extension of the heart to a permissible limit. The pericardial sac contains a small amount of fluid (pericardial fluid) which lubricates the movement of the heart inside the sac. Moreover, the cavity of the heart is lined by a delicate endothelial membrane known as **endocardium**. The mammalian heart consists of four chambers (left and right atria as well as their corresponding ventricles). There are two complete septa between the right and left sides of the heart, the inter-atrial septum and the inter-ventricular one. These septa separates each chamber from the others.

The thickness of each cardiac chamber is related to the strength of its contraction (systole). The walls of the atria (auricles) are thin as they pump the blood into the ventricles. In fact the main function of the atria is to act as reservoirs that

accommodate the blood received from the veins during the ventricular systole. The ventricular walls are thicker than that of the atria and the left ventricular wall is thicker and stronger than that of the right ventricle. Though both ventricles pump nearly the same quantity of blood per minute, yet the resistance to the flow of blood through the systemic circulation is higher than that through the pulmonary one.

The right side of the heart is considered a venous side as it receives the venous blood from the different parts of the body via the anterior and posterior venae cavae. This blood is pumped to the lungs through the pulmonary artery, in order to convert it into oxygenated blood. This is called lesser or pulmonary circulation. On the other side, the left half is an arterial one because it receives the oxygenated blood, through the pulmonary veins, and pump it into the tissues via the aorta and the arterial tree. This circulation is known as **greater** or **systemic** circulation.

Between each atrium and its corresponding ventricle there is an opening called **atrio-ventricular** opening (right and left) which communicates the two cavities of the atrium and its ventricle. On the right side this opening is guarded by tricuspid valve, while the left opening is guarded by bicuspid or mitral valve. The flaps of each valve are attached to papillary muscles (which are projections from the ventricular walls into the ventricular cavity), by means of slender cords (chordae tendinae). The atrioventricular valves (right and left) allow the passage of blood in one direction from the atrium toward its corresponding ventricle and prevent regurgitation of blood to the atria especially during ventricular systole. Moreover, during ventricular systole the papillary muscle contract and pull the flaps of the atrio-ventricular valves leading to prevent the inversion of these flaps into the atria. The aorta which arises from the left ventricle and the pulmonary artery which arises from the right ventricle are also supplied with valves called semilunar valves of three cusps. These valves are located at the openings of the aorta and the pulmonary artery. They control the passage of blood from the two ventricles to their corresponding arteries in one direction, as these valves are opened during ventricular systole and become closed when the heart relaxes (diastole).

N.B. *all most of veins are connected to*

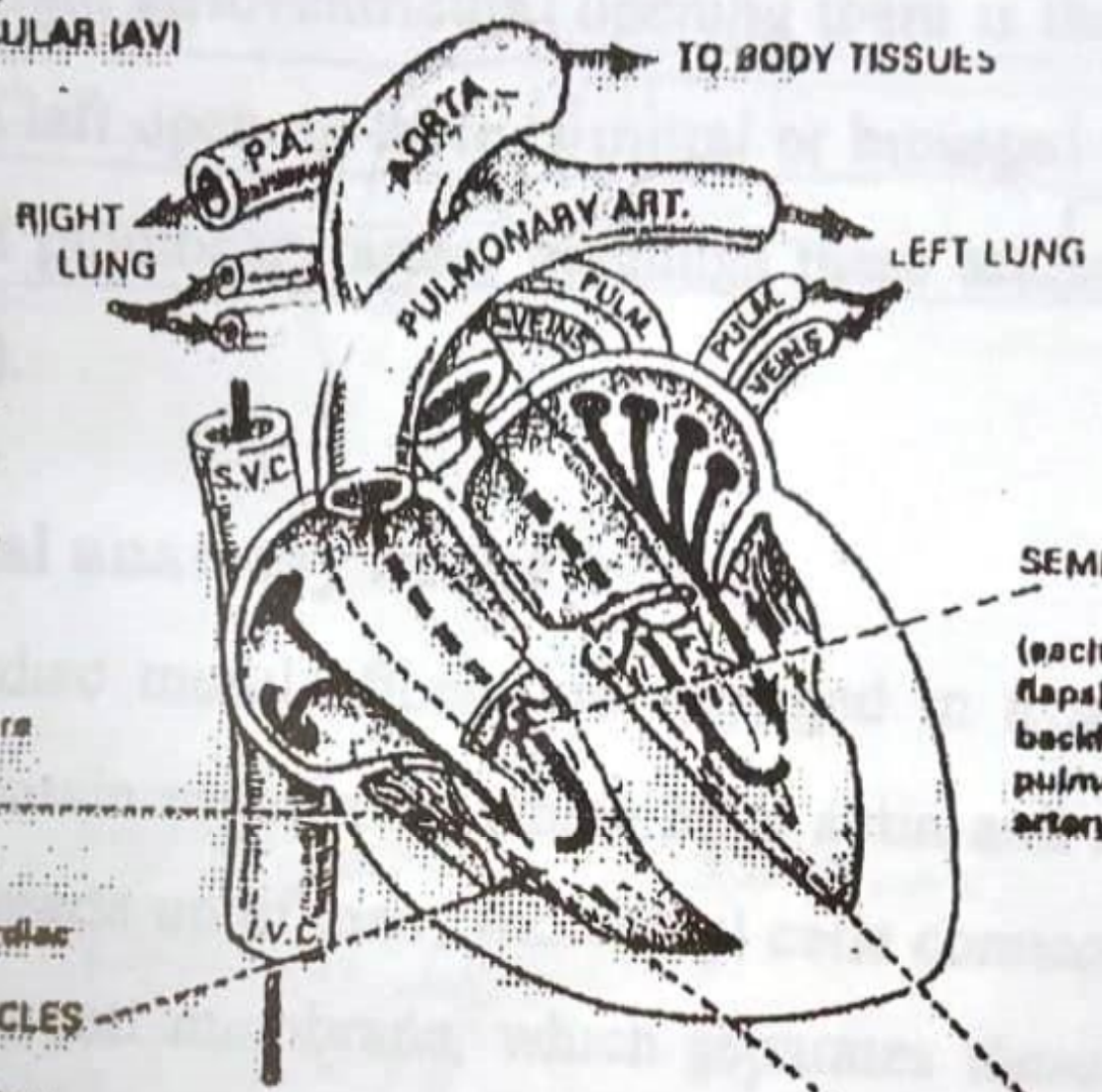
HEART VALVES have a core of fibrous tissue covered on both sides with Endothelium

Extensions from **ATRIO-VENTRICULAR (AV) FIBROUS RING**

Designed to allow blood to flow in one direction only - from atrium to ventricle - and on into arteries

The AV valves are attached by thin **CHORDAE TENDINEAE** to extensions of cardiac muscle - **PAPILLARY MUSCLES**

These contract when ventricles contract and pull on Chordae Tendineae so that valve flaps cannot be everted into atria.



SEMILUNAR VALVE (each with the flaps) prevent backflow from pulmonary artery and aorta

TRICUSPID VALVE

MITRAL VALVE

Annulus fibrosus

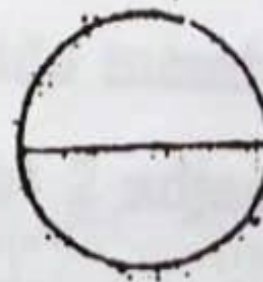


Fig. 2: Diagrammatic section through the heart

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Cardiac Cycle

- The work of the heart consists of rhythmic contraction and relaxation of the two auricles and the two ventricles.
- The contraction phase is called systole and the relaxation phase is called diastole.
- At first the two auricles contract followed by the contraction of the two ventricles and never the auricles and the ventricles contract simultaneously.
- The sequence of one systole followed by one diastole is called cardiac cycle which lasts 0.8 of a second.

and included three phases which are:-

Phase I:

Simultaneous contract of the two auricles, so the AV valves open (tricuspid and bicuspid) allowing blood to flow into the ventricles which are relaxing. This phase lasts 0.1 of a second.

Phase II:

Simultaneous contract of the two ventricles, causing the closure of the AV valves and at the same time the semilunar valves open and the blood is ejected (forced) into the aorta and the pulmonary artery. In this time the two auricles are relaxing. This phase lasts 0.3 of a second.

Phase III:

In this phase both the ventricles and the auricles are relaxing, thus it is called the general pause. During this phase the blood enters the auricles via the venous vessels. This phase lasts 0.4 of a second.

Heart Sound

The heart has two sounds which can be heard by an instrument called stethoscope

1. Systolic sound

This is due to the sudden closure of the AV valves at the beginning of systole of the ventricle

2. Diastolic sound

This is due to the sudden closure of the semilunar valves at the beginning of diastole of the ventricle

The heart sounds give information about the cardiac rate (rapid or slow) and the condition of the cardiac valves

- Damage of the AV valves lead to regurgitation of blood into the auricles producing abnormal sounds. Looks like the sound produced by the running water known as heart murmur

The intensity of the heart sounds has a great medical importance. For ex. when the intensity decreases, this may indicate emphysema or obesity.

Heart Beat

The function of the heart is the rhythmic pumping of blood which receives from the veins (venae cavae and pulmonary veins) into the arteries (aorta and pulmonary artery). This function is accomplished by the rhythmic contraction and relaxation of the cardiac muscular wall. These contractions and relaxations called heart beats.