Histology of Cardiovascular System

Abdullah Hazrati

MSc of anatomy in Tabriz Medical University Iran

ABSTRACT

The cardiovascular system is a transport system that carries blood and lymph to and from the tissues of the body. The constitutive elements of these fluids include cells, nutrients, waste products, hormones, and antibodies. The cardiovascular system consists of a pump represented by the heart and blood vessels, which provide the route by which blood circulates to and from all parts of the body. The heart pumps the blood through the arterial system under significant pressure; blood is returned to the heart under low pressure with the assistance of negative pressure in the thoracic cavity during inspiration and compression of the veins by skeletal muscle. The blood vessels are arranged so that blood delivered from the heart quickly reaches a network of narrow, thin-walled vessels, the blood capillaries, within or in proximity to the tissues in every part of the body. In the capillaries, a two-directional exchange of fluid occurs between the blood and tissues. The fluid, called blood filtrate, carries oxygen and metabolites, passes through the capillary wall. In the tissues, these molecules are exchanged for carbon dioxide and waste products. Most of the fluid reenters the distal or venous end of the blood capillaries. The remaining fluid enters lymphatic capillaries as lymph and is ultimately returned to the bloodstream through a system of lymphatic vessels that join the blood system at the junction of the internal jugular veins with the subclavian veins. Normally, many of the white blood cells conveyed in the blood leave the blood vessels to enter the tissues. This occurs at the level of the postcapillary venules. When pathologic changes occur in the body, as in the inflammatory reaction, large numbers of white blood cells emigrate from these venules.

INTRODUCTION

Arteries are the vessels that deliver blood to the capillaries. The smallest arteries, called arterioles, are functionally associated with networks of capillaries into which they deliver blood. The arterioles regulate the amount of blood that enters these capillary networks. Together, the arterioles, associated capillary network, and postcapillary venules form a functional unit called the microcirculatory or microvascular bed of that tissue. Veins, beginning with the postcapillary venule, collect blood from the microvascular bed and carry it away.

Two circuits distribute blood in the body: the systemic and the pulmonary circulations:

Two pathways of circulation are formed by the blood vessels and the heart:

- **pulmonary circulation** conveys blood from the heart to the lungs and from the lungs to the heart.
- **Systemic circulation** conveys blood from the heart to other tissues of the body and from other tissues of the body to heart.

Although the general arrangement of blood vessels in both circulations is from arteries to capillaries to veins, in some parts of the systemic circulation it is modified so that a vein or an arteriole is interposed between two capillary networks; these vessels constitute portal systems. Venous portal systems occur in vessels carrying blood to the liver, namely, the hepatic portal system (Portal vein), and in vessels leading to the pituitary, the hypothalamic- hypophyseal portal system.

**Analysis of heart system:**

The heart contains four chambers, the right and left atria and right and left ventricles, through which blood is pumped. Valves guard the exits of the chambers, preventing backflow of blood. An intracardial septum and an interventricular septum separate the right and left sides of the heart. The right atrium receives blood returning
from the body via the inferior and superior venae cavae, the two largest veins of the body. The right ventricle receives blood from the right atrium and pumps it to the lungs for oxygenation via the pulmonary arteries. The left atrium receives the oxygenated blood returning from the lungs via the four pulmonary veins. The left ventricle receives blood from the left atrium and pumps it into the aorta for distribution into the systemic circulation.

The walls of the heart contain:

- A musculature of cardiac muscle for contraction to propel the blood.
- A fibrous skeleton, which 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. The fibrous rings are composed of dense irregular connective tissue. They encircle the base of the two arteries leaving the heart (aorta and pulmonary trunk) and the openings between the atria and the ventricles. [4]

These rings provide the attachment site for the leaflets of all four valves of the heart that allow blood flow in only one direction through the openings. The membranous part of the interventricular septum is devoid of cardiac muscle; it consists of dense irregular connective tissue that contains a short length of the unbranched A-V bundle of the conducting system of the heart. The fibrous skeleton provides independent attachments for the atrial and ventricular myocardium. It also acts as an electrical insulator by preventing the free flow of electrical impulses between atria and ventricles.

- An impulse-conducting system of the heart for initiation and propagation of electrical impulses for cardiac muscle contraction. It is formed by highly specialized cardiac muscle cells (Purkinje fibers), which generate and conduct electrical impulses rapidly through the heart.

**General features of arteries and veins:**

The walls of arteries and veins are composed of three layers called tunics:

The three layers of the vascular wall, from the lumen outward are:

- Tunica intima, the innermost layer of the vessel. It consists of three components: (a) a single layer of squamous epithelial cells, the endothelium; (b) the basal lamina of the endothelial cells; and (c) the subendothelial layer, consisting of loose connective tissue. Occasional smooth muscle cells are found in the loose connective tissue. The subendothelial layer of the intima in arteries and arterioles contains a sheetlike layer or lamella of fenestrated elastic material called the internal elastic membrane. Fenestrations enable substances to diffuse readily through the layer and reach cells deep within the wall of the vessel. [4]

- Tunica media, the middle layer. This layer consists primarily of circumferentially arranged layers of smooth muscle cells. In arteries, it is relatively thick and extends from the internal elastic membrane to the external elastic membrane. The external elastic membrane is a layer of elastin that separates the tunica media from the tunica adventitia. Variable amounts of elastin, reticular fibers, and proteoglycans are interposed between the smooth muscle cells of the tunica media. The sheets or lamellae of elastin are fenestrated and are arranged in circular concentric layers. All of the extracellular components of the tunica media are produced by the smooth muscle cells.

- Tunica adventitia, the outermost connective tissue layer. It is composed primarily of longitudinally arranged collagenous tissue and a few elastic fibers. These connective tissue elements gradually merge with the loose connective tissue surrounding the vessels. The tunica adventitia ranges from relatively thin in most of the arterial system to dune chid: in the venules and veins, where it is the major component of the vessel wall. In addition, the tunica adventitia of large arteries and veins contains a system of vessels, called vasa vasorum, that supply blood to the vascular walls themselves, as well as a network of autonomic nerves, called nervi vascularis, that control contraction of the smooth muscle in the vessel walls. [3]

Histologically, the various types of arteries and veins are distinguished from each other on the basis of the thickness of the vascular wall and differences in the composition of the layers.

**Studding about capillaries:**

Capillaries are the smallest diameter blood vessels, often smaller than the diameter of an erythrocyte.

Capillaries form blood vascular networks that allow fluids containing gases, metabolites, and waste products to move through their thin walls. The human body contains approximately 50,000 miles of capillaries. Each consists of a single layer of endothelial cells and their basal lamina. The endothelial cells form a tube just large enough to allow the passage of red blood cells one at a time. In many capillaries the lumen is so narrow that the red cells literally fold on themselves to pass through the vessel. The passing red blood cells fill virtually the entire capillary lumen, minimizing the diffusion path for gases and nutrients between the capillary and the extravascular space. In cross sections and with the TEM, the tube appears to be formed by only one cell or portions of several cells, because of their thin walls and close physical association with metabolically active cells and tissues. Capillaries are particularly well suited for the exchange of gases and metabolites between cells and the bloodstream. The ratios of capillary volume to endothelial surface area and thickness also favor movement of substances across the vessel wall [2].
Lymphatic vessel:
Lymphatic vessels convey fluids from the tissues to the bloodstream:
In addition to blood vessels, another set of vessels circulates fluid, called lymph, through most parts of the body. These Lymphatic vessels serve as adjuncts to the blood vessels. Unlike the blood vessels, which convey blood to and from tissues, the lymphatic vessels are unidirectional, conveying fluid only from tissues. The smallest lymphatic vessels are called lymphatic capillaries. They are especially numerous in the loose connective tissues under the epithelium of the skin and mucous membranes. The lymphatic capillaries begin as "blind-ended" tubes in the microcapillary beds. Lymphatic capillaries converge into increasingly larger vessels, called lymphatic vessels. They ultimately unite to form two main channels that empty into the blood vascular system by draining into the large veins in the base of the neck. Lymph enter the vascular system at the junctions of the internal jugular and subclavian veins. The largest lymphatic vessel, draining most of the body and emptying into the veins on the left side, is the thoracic duct. The other main channel is the right lymphatic trunk.4

Conclusion:
1. Cardiac muscle can contract in a rhythmic manner without any direct stimulus from the nervous system. The electrical activity that results in the rhythmic pulsations of the heart is initiated within the heart itself.
2. The impulse is then picked up at the A-V node and conducted across the fibrous skeleton to the ventricles by the A-V bundle (of His).
3. Fibrosa forms the core of the valve and contains fibrous extensions Gram the dense irregular connective tissue of the skeletal rings of the heart.

REFERENCES