VASCULAR SYSTEM

- The cardiovascular system is concerned with the transport of blood and lymph through the body. It may be divided into four major components: the heart, the macrocirculation, the microcirculation and the lymph vascular system.
- The main functions of the blood are to transport oxygen, nutrients and hormones to the tissues and to collect the waste products (carbon dioxide and waste metabolites) for removal from the body via the excretory system.

The cardiovascular system consists of the:

- Heart (muscular pump)
- Pulmonary circulation (system of blood vessels to and from the lungs)
- Systemic circulation (system of blood vessels bringing blood to and from all the other organs of the body).

- **Conducting (Elastic Arteries).** These are large arteries closest to the heart (aorta, renal artery) with very high blood pressure and flow (320mm/sec in the aorta).
- **Distributing (Muscular Arteries).** These are smaller diameter arteries with a slower blood flow .The arteries lead to smaller vessels, the arterioles, which lead to the capillaries.
- **The capillaries** are present in the form of microcirculation networks (capillary beds) in the organs and tissues. Exchange of metabolites and transport through the vessel wall is only possible in the capillaries, as only here the blood flow is sufficiently reduced (about 0.3mm/sec) and the vessel wall sufficiently thin.

The arterial wall is composed of three main layers or tunics:-

- ✓ **Tunica intima** (internal tunic) consisting of :
  Endothelium (single lining layer of endothelial cells) sub-endothelial layer inner elastic limiting membrane (elastic lamina, which after fixation.

✓ **Tunica media** (middle tunic) consisting of :
- circular smooth muscle (or spiral)
- Concentric elastic lamina (formed by the smooth muscle cells).

✓ **Adventitia** (outer layer) composed of :
Connective tissue surrounding the vessel

- The tunica media is the main site of histological specialisations in the walls of arteries.
- The tunica media is formed by a layer of circumferential smooth muscle and variable amounts of connective tissue. A second layer of elastic fibers, the external elastic lamina, is located beneath the smooth muscle. It delimits the tunica media from the tunica adventitia, which consist mainly of connective tissue fibres.
- The tunica adventitia blends with the connective tissue surrounding the vessel.
- The definition of the outer limit of the tunica adventitia is therefore somewhat arbitrary.

Elastic arteries:

- The tunica intima of elastic arteries is thicker than in other arteries. A layer of loose connective tissue beneath the endothelium (subendothelial connective tissue) allows the tunica intima to move independently from other layers as the elastic arteries distend with the increase in systolic blood pressure
- The thin endothelial lining of the aorta corresponds to that of other vessels. The flattened cells are easily damaged during preparation and it may be difficult to identify the endothelium. The subendothelial layer of connective tissue is characterised by a lower density of cells, i.e. fewer nuclei, a fibrous appearance of the tissue and the absence of well-defined elastic layers
- Distension of the walls is facilitated by concentric fenestrated lamellae of elastic fibres in a thick tunica media. In adult humans, about 50 elastic lamellae are found in the tunica media of the aorta.

- Smooth muscle cells and collagen fibres are present between the layers of elastic fibres. Both fibre types are produced by the smooth muscle cells. Each elastic lamella forms together with interlamellar fibres and cells a lamellar unit. The external elastic lamina is difficult to discern from other layers of elastic fibres in the tunica media.
- The tunica adventitia appears thinner than the tunica media and contains collagen fibres and the cell types typically present in connective tissue. The walls of these large arteries are so thick that their peripheral parts cannot derive enough oxygen and nutrients from the blood of the vessel that they form.
- Larger vessels are therefore accompanied by smaller blood vessels which supply the tunica adventitia and, in the largest vessels, the outer part of the tunica media of the vessel wall. The vessels are called vasa vasorum. In macroscopic preparations vasa vasorum are visible as fine dark lines on the surface of the larger arteries.
- The majority of cells in the tunica media are smooth muscle cells. Smooth muscle cells and collagen fibres are found between the layers of elastic fibres.

  The diameter of individual arteries decreases as we follow them further into the periphery... The amount of elastic fibres in the tunica media decreases with these physiological changes

Muscular arteries:

- The tunica intima is thinner than in elastic arteries. Sub endothelial connective tissue other than the internal elastic lamina is often difficult to discern. The internal elastic lamina forms a well-defined layer. The tunica media is dominated by numerous concentric layers of smooth muscle cells. Fine elastic fibres and a few collagen fibres are also present.
- The external elastic lamina can be clearly distinguished although it may be incomplete in places. The thickness and appearance of the tunica adventitia is variable

Arterioles

- ✓ Are arterial vessels with a diameter below 0.1 - 0.5 mm
- ✓ Endothelial cells are smaller than in larger arteries, and the nucleus and surrounding cytoplasm may 'bulge' slightly into the lumen of the arteriole. The endothelium still rests on an internal elastic lamina, which may be incomplete and which is not always well-defined in histological sections.
- ✓ The tunica media consists of 1-3 concentric layers of smooth muscle cells. It is difficult to identify an external elastic lamina or to distinguish the tunica adventitia from the connective tissue surrounding the vessel.

Atherosclerosis

- Arteries of elastic type show greater changes with in advanced age than other types. Changes occur to the tunica intima and media.
- The elastic tissue shows irregularity, thickening, fragmented. Fat accumulate within the interstitial substances. Calcification
- Occur within the media of medium sized artery.

Capillaries

- ❖ The capillaries are very small vessels. Their diameter ranges from 4-15 µm. The wall of a segment of capillary may be formed by a single endothelial cell facilitate the functions of capillaries in providing nutrients and oxygen to the surrounding tissue, in the absorption of nutrients, waste products and carbon dioxide, and in the excretion of waste products from the body.
- ❖ These functions are also facilitated by a very simple organisation of the wall of capillaries. Only the tunica intima is present, which typically only consists of the endothelium, its basal lamina and an incomplete layer of cells surrounding the capillary, the pericytes. Pericytes have contractile properties and can regulate blood flow in capillaries. In the course of vascular remodelling and repair, they can also differentiate into endothelial and smooth muscle cells.

Three types of capillaries can be distinguished based on features of the endothelium

- Continuous capillaries are formed by "continuous" endothelial cells and basal lamina. The endothelial cell and the basal lamina do not form openings, which would allow substances to pass the capillary wall without passing through both the endothelial cell and the basal lamina. Both endothelial cells and the basal lamina can act as selective filters in continuous capillaries.

- Fenestrated capillaries:
  The endothelial cell body forms small openings called fenestrations, which allow components of the blood and interstitial fluid to bypass the endothelial cells on their way to or from the tissue surrounding the capillary. The fenestrations may represent or arise from pinocytotic vesicles which open onto both the luminal and basal surfaces of the cell. The extent of the fenestration may depend on the physiological state of the surrounding tissue, i.e. fenestration may increase or decrease as a function of the need to absorb or secrete. The endothelial cells are surrounded by a continuous basal lamina, which can act as a selective filter.

The exchange of materials through capillary walls can be:

- ✓ **transcellular** via :
  - micropinocytotic vesicles in the endothelium (as in continuous capillaries)
  - Fenestrations (as in fenestrated endothelium or sinusoids)
- ✓ Or **intercellular** via:
  - Gap junctions spaces between endothelial cells (as in sinusoids of spleen, liver).

Pericytes (Perivascular cells)

- Many capillaries have, elongated cells, similar in appearance to embryonic mesenchymal cells, associated with them. These cells, known as pericytes, or perivascular cells, are quite difficult to see in most histological preparations.
- These pericytes appear to have important roles in repair of blood vessels and connective tissue after injury. They have the potential to develop into fibroblasts, smooth muscle cells and may even be phagocytic.

Sinusoids

- Sinusoids are irregular vessels with large diameters (30-40nm). In most cases the sinusoids are not cylindrical. Sinusoids are found in the liver, endocrine glands and in the hematopoietic organs (bone marrow, spleen).
- In many cases the sinusoids are also fenestrated. This is the case in those organs which need a very rich blood supply including most of the endocrine glands (hypophysis, suprarenal cortex, and pancreas).
- Phagocytes are commonly associated with the walls of the sinusoids

Veins

The walls of veins are thinner than the walls of arteries, while their diameter is larger. In contrast to arteries, the layering in the wall of veins is not very distinct. The tunica intima is very thin. Only the largest veins contain an appreciable amount of subendothelial connective tissue. Internal and external elastic laminae are absent or very thin. The tunica media appears thinner than the tunica adventitia, and the two layers tend to blend into each other .Veins appear less rigid, less sturdy.

The appearance of the wall of veins also depends on their location. The walls of veins in the lower parts of the body are typically thicker than those of the upper parts of the body, and the walls of veins which are embedded in tissues that may provide some structural support are thinner than the walls of unsupported veins.

Venules

- ❖ They are larger than capillaries.Forms from the union of several capillaries (50 μ m)
- ❖ Small Venules are surrounded by pericytes.
- ❖ A few smooth muscle cells may surround larger Venules.
- ❖ The Venules merge to form, small to medium-sized veins which contain bands of smooth muscle in the tunica media. The tunica adventitia is well developed. In some veins the tunica adventitia contains longitudinally oriented bundles of smooth muscle.

- Most small to medium-sized veins especially those of the limbs are also characterised by the presence of valves. The valves are formed by loose, pocket-shaped folds of the tunica intima, which extend into the lumen of the vein. The opening of the pocket will point into the direction of blood flow towards the heart. One to three (usually two) pockets form the valve.
- The ability of the valves to prevent backflow depends to some extent on the state of contraction (tone) of the smooth muscle in the wall of the vein.
- The largest veins of the abdomen and thorax do contain some sub endothelial connective tissue in the tunica intima, but both it and the tunica media are still comparatively thin. Collagen and elastic fibres are present in the tunica media. The tunica adventitia is very wide, and it usually contains bundles of longitudinal smooth muscle. The transition from the tunica adventitia to the surrounding connective tissue is gradual. Valves are absent.

Blood vessels of Blood vessels (Vasa Vasorum)

- ➢ Arteries and vein with diameter over 1 mm are supplied with small nutrient blood vessels called (Vasa Vasorum), these vessels enter the adventitia and terminate to the deepest part of the media . In arteries no capillaries are found in the t. intima it is nourished from the blood in the lumen. Except in large vein.
- ➢ Vasa vasorum are more frequent in the walls of large veins than in that of the corresponding arteries - probably because of the lower oxygen tension in the blood contained within them.

Arteriovenous anastomoses

These represent direct connections between arterioles and venules. When there is no need for blood flow in the capillary bed these permit direct blood passage (arterial-venous-shunt). Arteriovenous anastomoses are very common in the dermis of the skin.

Anastomoses are of 2 types:

1. **Indirect - Hoyer (Glomus or Shunt)** in which Arterioles connected to venules by connecting vessel which is small arteriole branched into 6 branches arranged in circular ,manner found in lips, finger tips , toes nose , nail bed, palm of the hand, sole of the foot.
   arteriovenous shunts, which can shunt the blood flow that otherwise would enter the capillary network between the vessels. These shunts usually contain specialisations of the smooth muscle in the region of the shunt.
2. **Direct Anastomosis**: In this type the arteriol connect to venule directly no connecting vessel. It is found in Thyroid gland , alimentary canal

Functions of the Lymph Vascular System

- The lymph vessels return to the blood extracellular fluid from connective tissue spaces. This system ensures the return of water, electrolytes and plasma proteins to the blood.
- The lymph vascular system plays a role in homeostasis of the volume of extracellular fluid.
- The lymph vascular system also returns lymphocytes from the lymph nodes to the blood.
- The system also transports immunoglobulins (antibodies) from the lymph nodes to the blood

Lymphatic Vessels

- Parts of the blood plasma will exude from the blood vessels into the surrounding tissues because of transport across the endothelium or because of blood pressure and the fenestration of some capillaries (this process is partly counteracted by the higher osmotic pressure of the blood).

- The fluid entering tissues from capillaries adds to the interstitial fluid normally found in the tissue. The liquid needs to be returned to the circulation, the lymph.
- Three types of lymph vessels can be distinguished based on their size and morphology.
- Lymph capillaries are somewhat larger than blood capillaries and very irregularly shaped. Broader, Thinner
- The basal lamina is almost completely absent
- No pericyte in the lymph capillary. Circulation via lymph vessels which are found in the villi of the ileum and jejunum). Lymph capillaries merge to form lymphatic vessel
- Lymph collecting vessels which are larger and form valves but otherwise appear similar to lymph capillaries. The lymph is moved by the compression of the lymph vessels by surrounding tissues. The direction of lymph flow is determined by the valves. Lymph vessels empty intermittently into lymph nodes from which the lymph continues in efferent lymph vessels.

The heart

- The heart is modified Blood vessel
- Consist of 4 chambers 2 Ateria and 2 ventricles.
- On the right side the atrium receives blood from the body and the ventricle propel it to the lungs.
- On the Left side the atrium receive the blood from the lungs and the left ventricles distribute it throughout the body.
- The middle layer or tunica media: myocardium; comprises almost whole mass of heart cardiac muscles , arranged in layers become thickest in left ventricles and thinnest in atria., they arranged in bundles in atria .
- The Epicardium or the visceral layer or the serous membrane: = visceral pericardium = serosa: covered by mesothelium; and c.t underneath a layer of areolar c.t. With blood v., nerves fibers and fat.
- Purknje fibers in specialized cardiac muscle fibers its function is to coordinate heart beat by regulating the contraction of atria and ventricles.
- They have faster rate of conduction than the ordinary cardiac ml. Thicker, larger diameter, more sarcoplasm, and more glycogen.
- In advanced age they lose their features and transfer into ordinary cardiac ml.