

Cardiovascular system

Vascular system:

It is a network of tubular passages runs through the connective tissues, through which the more fluid components of the extracellular environment flow. The fluid is either blood forming **blood vascular system** which is formed of heart, arteries & veins or lymph forming **lymphatic vascular system**.

Blood Vascular System

Classification of blood vessels:

Blood vessels are classified into **4 classes**:

1. **Arteries:** These are thick-wall, contractile & elastic vessels, structured to distribute blood rapidly under high pressure.
2. **Veins:** These are thin, tough-walled larger vessels, structured to store & retrieve (get back) blood for use by the heart.
3. **Capillaries:** These are networks of small & uniform thin-walled tubules structured for interchange molecules & cells between the blood & the interstitial spaces.
4. **Sinusoids:** These are large, irregular, thin-walled structures, planned for interchange molecules & cells between the blood & the interstitial spaces. They are found in few organs such as liver, spleen & bone marrow.

Arteries:

In the cross section it showed triple-layered walls.

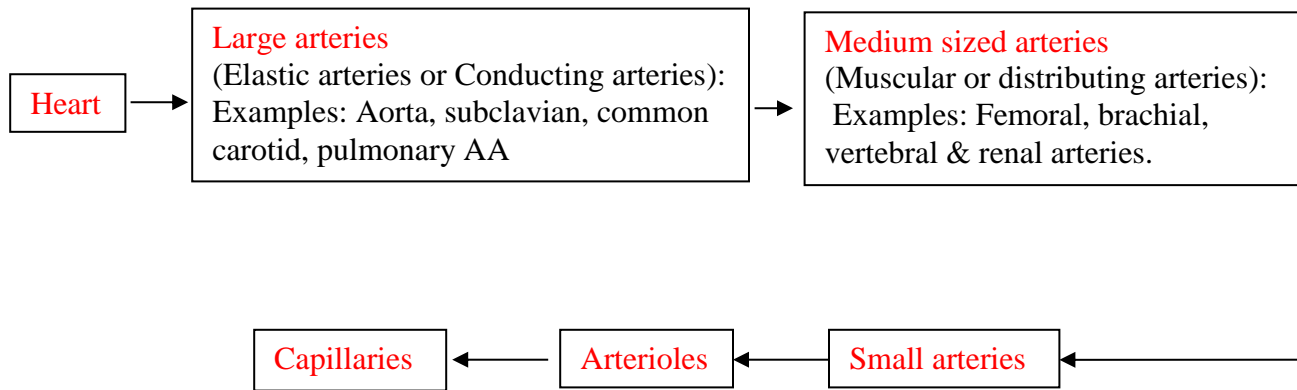
1. **Tunica intima** (internal tunic or inner tunic).
2. **Tunica media** (middle tunic).
3. **Tunica adventitia** (external tunic or outer tunic).

Tunica intima: it includes the followings:

- a. **Endothelium:** it is the inner lining cells.
- b. **Sub endothelial connective tissue** which contains collagen fibers or sheet of elastic fibers. Usually the elements are all oriented parallel to the long axis of the vessel.

Tunica media: It is composed of connective tissue, layers of smooth muscle fibers and /or elastic connective tissue. Its orientation is opposite to those of tunica intima. Its elements are arranged at right angles to the long axis of the vessel.

Tunica adventitia: It is composed of fine elastic & collagen fibers joining the vessel to the surrounding connective tissues.



Elastic Arteries:

1. **T. intima** is usually **thicker** than those of the other types of arteries.
 - a. **Endothelial lining cells** are polygonal, while thinner squamous forms seen in the smaller vessels.
 - b. **Subendothelial connective tissue layer** contains fibroblasts; collagen & numerous fine longitudinally oriented elastic fibers.
2. **T. media** is the **thickest** of the three layers in the elastic arteries. It consists primarily of concentrically arranged, fenestrated **elastic laminae**. Smooth muscle fibers lie between the adjacent elastic laminae. Fine collagen & elastic fibers are present between the laminae. The intercellular substance is far more **basophilic** due to great amount of sulfated mucopolysaccharides.
3. **T. adventitia** has less elastic fibers & more collagen fibers than that of the other 2 layers. Small blood vessels (**Vasa vasorum**), fine nerves (**Nervi vasorum**) supply the thick walls of the large arteries.

Muscular Arteries: these are the most **numerous types** of arteries.

1. **T. intima** consists of endothelium lying directly on the thick **internal elastic lamina** with little connective tissue interposed (this lamina is not clear in the large arteries because of their thick tunica media).
2. **Thick T. media** is composed mainly of **smooth muscle cells** arranged in concentric layers ranged from 2 to more than 40 cell-layers thick. Elastic fibers and collagen fibrils are usually present between them.
3. **T. adventitia** is sometimes thicker than the media. It consists of fibroblasts, longitudinal strands of elastic fibers.

Differences between large (elastic) & medium sized (muscular) arteries:

	Large or elastic arteries	Medium sized or muscular arteries
1.	Tunica intima is thickest	Less in thickness
2.	Internal & external elastic laminae not clear because the tunica media have many elastic fibers.	They are very clear
3.	Tunica media composed mainly of numerous elastic laminae	Tunica media composed mainly of smooth muscle cells or fibers.
4.	Tunica adventitia has clear vasa vasorum, nervi vasorum	Not have vasa vasorum, nervi vasorum
5.	Have larger lumen	Have smaller lumen

Small arteries:

They are showed thin tunica media & tunica adventitia and the amount of elastic tissues is reduced significantly. The endothelial cell nuclei bulge prominently into the lumen. Internal elastic laminae may appear as thin line. External elastic lamina is not so clear. The muscularity of the tunica media is counting about 5 or 6 layers of smooth muscle.

Arterioles:

They are similar to small arteries but their internal & external elastic laminae are not clear. They have up to 3 layers of smooth muscle in the tunica media. The tunica adventitia is blend in completely with surrounding connective tissue.

Capillaries:

1. These are tubules with uniform diameter (nearly 8 μm wide), constructed essentially of endothelial cells surrounded by basal lamina & pericytes. Their walls are of 2 layers:
 - a. Tunica intima of one or two squamous endothelial cells resting on basal lamina.
 - b. Fine tunica adventitia of collagen & elastic fibers, surrounded by pericytes.
2. The basal lamina is continuous yet porous to molecules with molecular weights less than 70000. Thus it serves as a molecular sieve against large protein molecules.

Pericytes:

These are undifferentiated perivascular cells. They have primitive cytological characteristics including ease of mitotic stimulation & migration around or away from the capillaries.

Sinusoids:

Present in the liver, spleen & bone marrow they are different structurally & functionally from the capillaries.

	Sinusoids	Capillaries
1.	Larger lumen	smaller lumen
2.	Lack uniformity in diameter	Uniform in diameter
3.	More permeable than capillaries	Less permeable than sinusoids
4.	Shape themselves to fill the space present within the connective tissue of the surrounding parenchyma	not
5.	Blood flow through them is very slow to zero.	Minimum blood flow but higher than sinusoids
6.	Have large opening between sinusoidal cells for a maximum exchange between blood & surrounding parenchyma.	Have not this character

Veins:

Veins are classified into:

- a. Venules which are leading from capillary beds.
- b. Small veins.
- c. Medium sized veins, which are corresponds to distributed arteries called **collective veins**.
- d. Large veins, which are corresponds to aorta called great veins such as vena cava & jugular veins.

Venules:

1. They have large lumen. Structurally similar to capillaries but have larger diameter (usually 20 μm in diameter opposite to 8 μm in capillaries).
2. There is marked tunica adventitia extends to the endothelial basement membrane, composed of few collagen fibers, an occasional fibroblasts & pericytes.
3. The junctions between endothelial cells are more permeable than those in capillaries & more sensitive to leakage caused by agents such as histamine, serotonin. These compounds play a role in inflammatory reactions leads to excessive accumulation of extravascular fluid.
4. Venules are a definite site for large molecules exchange between the vascular & connective tissue spaces.

Small veins:

Circularly oriented smooth muscle fibers appeared between tunica adventitia & the endothelium forming an incomplete tunica media.

Medium-sized veins:

1. They have typical three-layered walls.
2. Muscle fibers are generally arranged in one or two layers between the tunica intima & tunica adventitia (usually the inner one is spiral & the outer layer is longitudinal in direction).
3. Internal & external elastic laminae are seldom clearly represented in veins; instead, the sparse elastic fibers are more randomly distributed among the more prevalent collagen fibers.
4. Both small & medium-sized veins, especially those of the extremities are equipped with flap-like, usually paired, **semilunar valves** that close to prevent the back-flow of blood.

Large veins:

1. Tunica intima consists of an endothelium of polygonal simple squamous cells, with subendothelial connective tissue layer of collagen fibers & fibroblasts.
2. Tunica media is thin & consists only of a few layers of smooth muscle cells. This layer may be even be lacking.
3. Tunica adventitia is prominent & composed of longitudinally or spirally oriented bundles of smooth muscle cells together with collagen & elastic fibers.

	Large artery	Large vein
1	Lumen: smaller	Lumen: larger
2	Tunica intima: thicker	Tunica intima: thinner
3	Internal & external elastic laminae: present	Internal & external elastic laminae: seldom
4	Tunica media: thickest and contain numerous elastic laminae	Tunica media: Thin or absent of tunica media, If present contain smooth muscle fibers
5	Tunica adventitia: Thinner and contain only elastic & collagen fibers	Tunica adventitia: Thicker, contain bundles of smooth muscle fibers and elastic & collagen fibers

	Venules	arterioles	capillaries
1	Larger lumen	Smaller lumen	Smaller lumen
2	Larger diameter	Smaller diameter	Smaller diameter
3	Have marked tunica adventitia	Have marked tunica media of 2-3 layers of smooth muscle fibers	Have only 2-3 endothelial cells with pericytes
4	More permeable	not permeable	Less permeable

	Large vein	Medium sized vein
1	Tunica media: very thin or lack	Smooth muscle bundles arranged into inner (spiral) & outer longitudinal layers
2	Tunica adventitia: Prominent layer of smooth muscle bundles	Not prominent, no s.m.f.