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Tissues of the vascular wall

Introduction

1-The circulatory system is divided into two parts:

A- Cardiovascular system   B- Lymphatic System

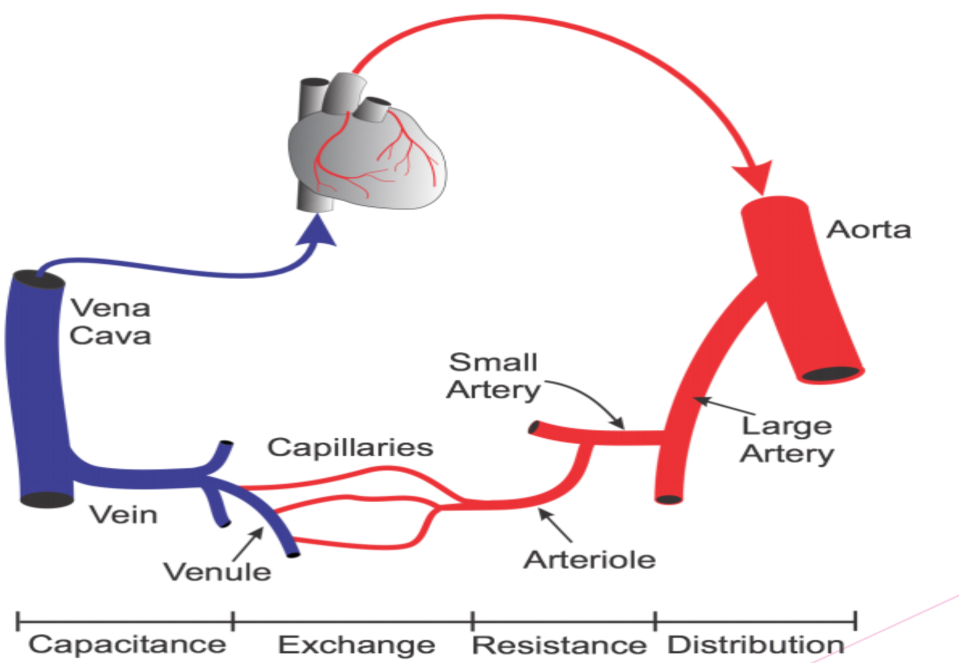
2- We must know the difference between an artery and a vein:

-An artery carries blood away from the heart and its structure must be adapted to high pressure and must have high flexibility, whereas a vein carries blood back to the heart and its structure must fit its function.

3-Walls of all blood vessels except capillaries contain smooth muscle and connective tissue in addition to the endothelial lining.

4-The amount and arrangement of these tissues in vessels are influenced by mechanical factors, primarily blood pressure, and metabolic factors reflecting the local needs of tissues.

5- This picture is a brief summary of blood pathway :



6- All vessels have a lumen and are lined by simple squamous epithelium called “endothelium” and it is the special kind of epithelium which is allowed to attach to the blood .

Vessel layers

*Walls of both arteries and veins have three tunics called **tunica intima, tunica media, and tunica adventitia (or externa**), which correspond roughly to the heart’s endocardium, myocardium, and epicardium, but notice that vessels are not covered by mesothelium unlike the heart.

*An artery has a thicker media and relatively narrow lumen.

*A vein has a larger lumen and its adventitia is the thickest layer. The intima of veins is often folded to form **valves**, **why**? As veins work without the blood pump (the heart), they must have something to prevent the backflow of the blood especially when they're working against gravity and valves help them to carry out their function.

*Capillaries only have endothelium, with no subendothelial layer or other tunics ,so you can’t find smooth muscles.

Endothelium

Endothelium: The internal surface of all components of the blood and lymphatic systems is lined by a simple squamous epithelium called endothelium. The endothelium is a specialized epithelium that acts as a semipermeable barrier between two major internal compartments: the blood and the interstitial tissue fluid. Vascular endothelial cells are squamous, polygonal, and elongated with the long axis in the direction of blood flow.

Endothelium with its basal lamina is highly differentiated to mediate and actively monitor the bidirectional exchange of molecules by simple and active diffusion, receptor-mediated endocytosis and transcytosis.

Endothelium functions

1-Maintain a selectively permeable, antithrombogenic (inhibitory to clot formation) barrier “intact endothelium prevents clotting”

2-Determine when and where white blood cells leave the circulation for the interstitial space of tissues by markers related to the inflammation on epithelium

3- Secrete a variety of paracrine factors for vessel dilation, constriction, and growth of adjacent cells.

Smooth muscle fibers

Smooth muscle fibers occur in the walls of all vessels larger than capillaries and are arranged helically in layers.

In arterioles and small arteries, the smooth muscle cells are connected by many more gap junctions and permit vasoconstriction and vasodilation which are of key importance in regulating the overall blood pressure

Connective tissue components

Connective tissue components are present in vascular walls in variable amounts and proportions based on local functional requirements.

Collagen fibers are found in the subendothelial layer, between the smooth muscle layers, and in the outer covering.

Elastic fibers provide the resiliency required for the vascular wall to expand under pressure. Elastin is a major component in large arteries where it forms parallel lamellae, regularly distributed between the muscle layers.

Walls of the Vessels

Layer	Location	Components	In arteries
Tunica intima	Innermost layer	Endothelium, loose connective tissue, sometimes containing smooth muscle fibers.	In arteries the intima includes a thin layer, the internal elastic lamina, composed of elastin, with holes allowing better diffusion of substances from blood deeper into the wall.
Tunica media	Middle layer	concentric layers of helically arranged smooth muscle cells.	In arteries the media may also have an external elastic lamina separating it from the outermost tunic.
Tunica adventitia	Outer layer	connective tissue consisting principally of type I collagen and elastic fibers.	

note: there is layer between intima and media called **internal elastic lamina which is a fenestrated lamina, nutrients pass through it for smooth muscles

****tunica media** Interposed among the muscle fibers are variable amounts of elastic fibers and elastic lamellae, reticular fibers, and proteoglycans, all of which are produced by the smooth muscle cells.

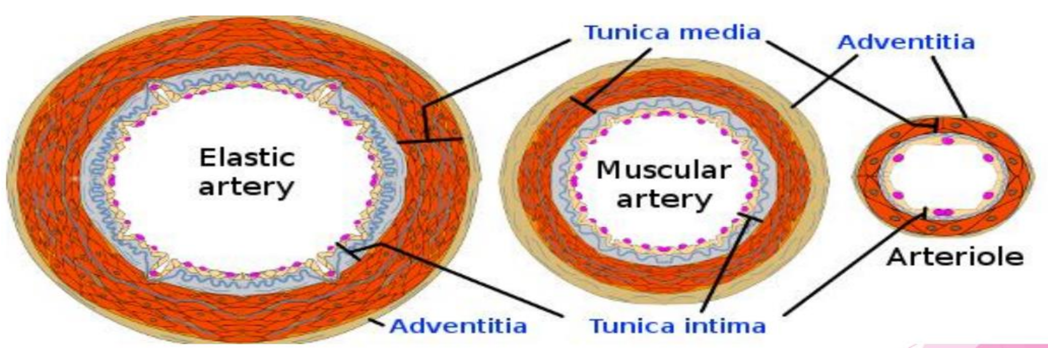
****The adventitia** is continuous with and bound to the stroma of the organ through which the blood vessel runs.

Vasa Vasorum (vessels of vessels)

How do vessels obtain nutrients?

Just as the heart wall is supplied with its own coronary vasculature for nutrients and O2, large vessels usually have vasa vasorum ("vessels of the vessel"): arterioles, capillaries, and venules in the adventitia and outer part of the media.

The vasa vasorum are required to provide metabolites to cells in those tunics in larger vessels because the wall is too thick to be nourished solely by diffusion from the blood in the lumen. Luminal blood alone does provide the needs of cells in the intima. Because they carry deoxygenated blood, large veins commonly have more vasa vasorum than arteries.



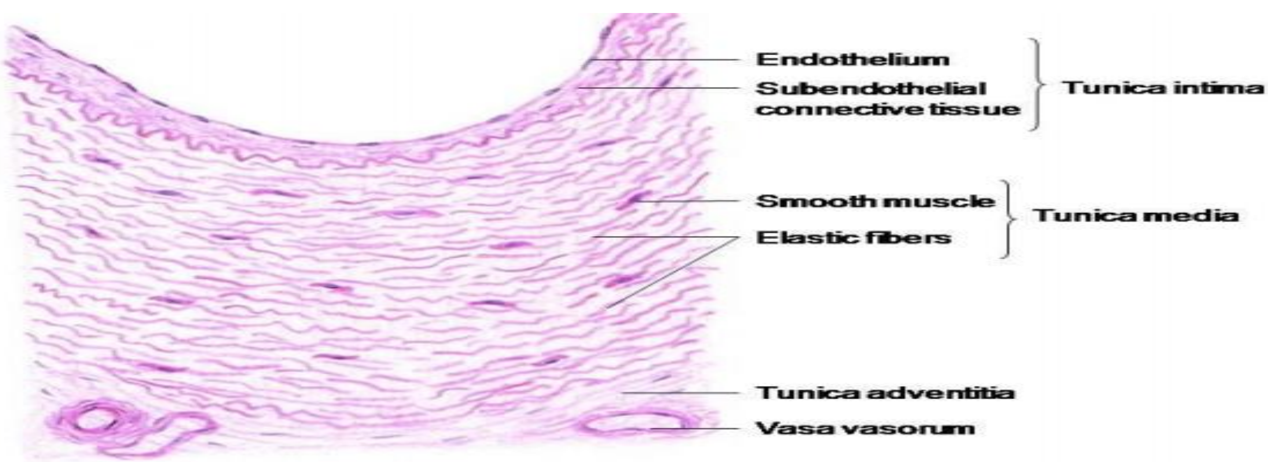
Vessels :

1) Elastic artery: elastic arteries are: a-the aorta , b-the pulmonary artery, c-their largest branches(**conducting arteries)** which carry blood to smaller arteries

*Feature: The most prominent feature of elastic arteries is the thick tunica media in which elastic lamellae alternate with layers of smooth muscle fibers.

*The adult aorta has about 50 elastic lamellae (more if the individual is hypertensive.

*Structure: **The tunica intima** is well developed, with many smooth muscle cells in the subendothelial connective tissue, and often shows folds in a cross section as a result of the loss of blood pressure and contraction of the vessel at death. Between the intima and the media is the **internal elastic lamina,** which is more well-defined than the elastic laminae of the media. **The adventitia** is much thinner than the media.

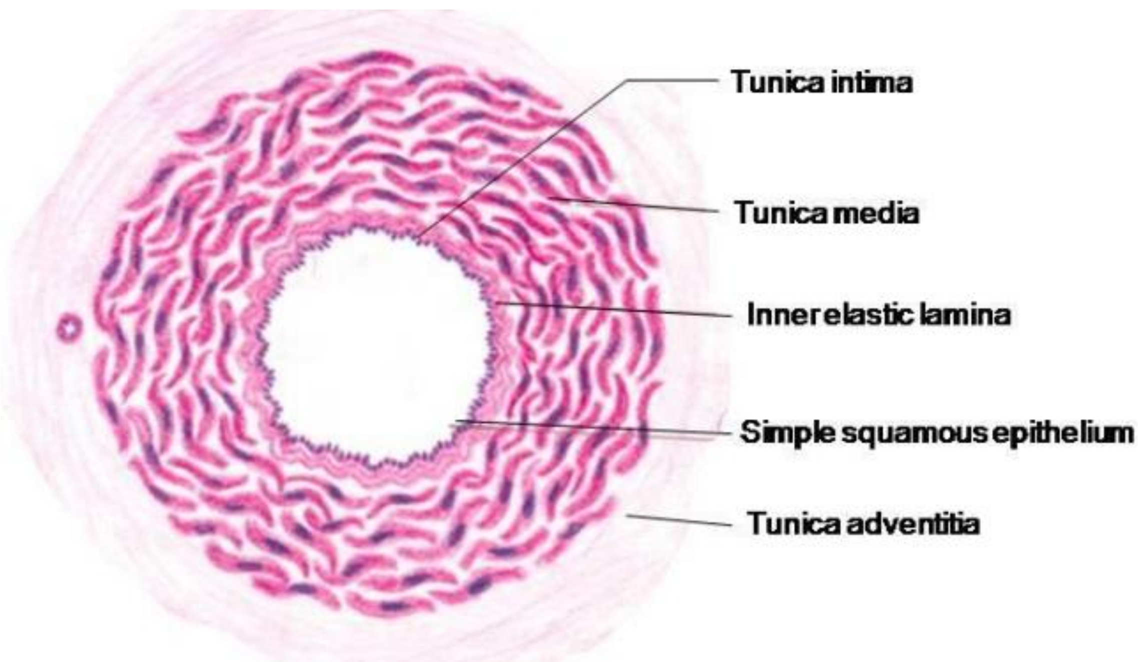


note: this picture is not true histologically, it is just for understanding the concept

2) Muscular artery: (distributing arteries)

*Function: to distribute blood to the organs and help regulate blood pressure by contracting or relaxing the smooth muscle in the media.

*Structure: **The intima** has a thin subendothelial layer and a prominent internal elastic lamina**. The media** may contain up to 40 layers of large smooth muscle cells interspersed with a variable number of elastic lamellae (depending on the size of the vessel). **An external elastic lamina** is present only in the larger muscular arteries**. The adventitial connective tissue** contains lymphatic capillaries, vasa vasorum, and nerves, all of which may penetrate to the outer part of the media. Examples: femoral artery, brachial artery.



3) Arteriole: They are smallest branches of arteries.

*Structure: only one or two smooth muscle layers; these indicate the beginning of an **organ's microvasculature**. Arterioles are generally less than 0.1 mm in diameter, with lumens approximately as wide as the wall is thick. The subendothelial layer is very thin. Elastic lamina is absent. **The media** consists of the circularly arranged smooth muscle cells. In both small arteries and arterioles, **the adventitia** is very thin.

*Physiologically: These vessels are the major determinants of systemic blood pressure.

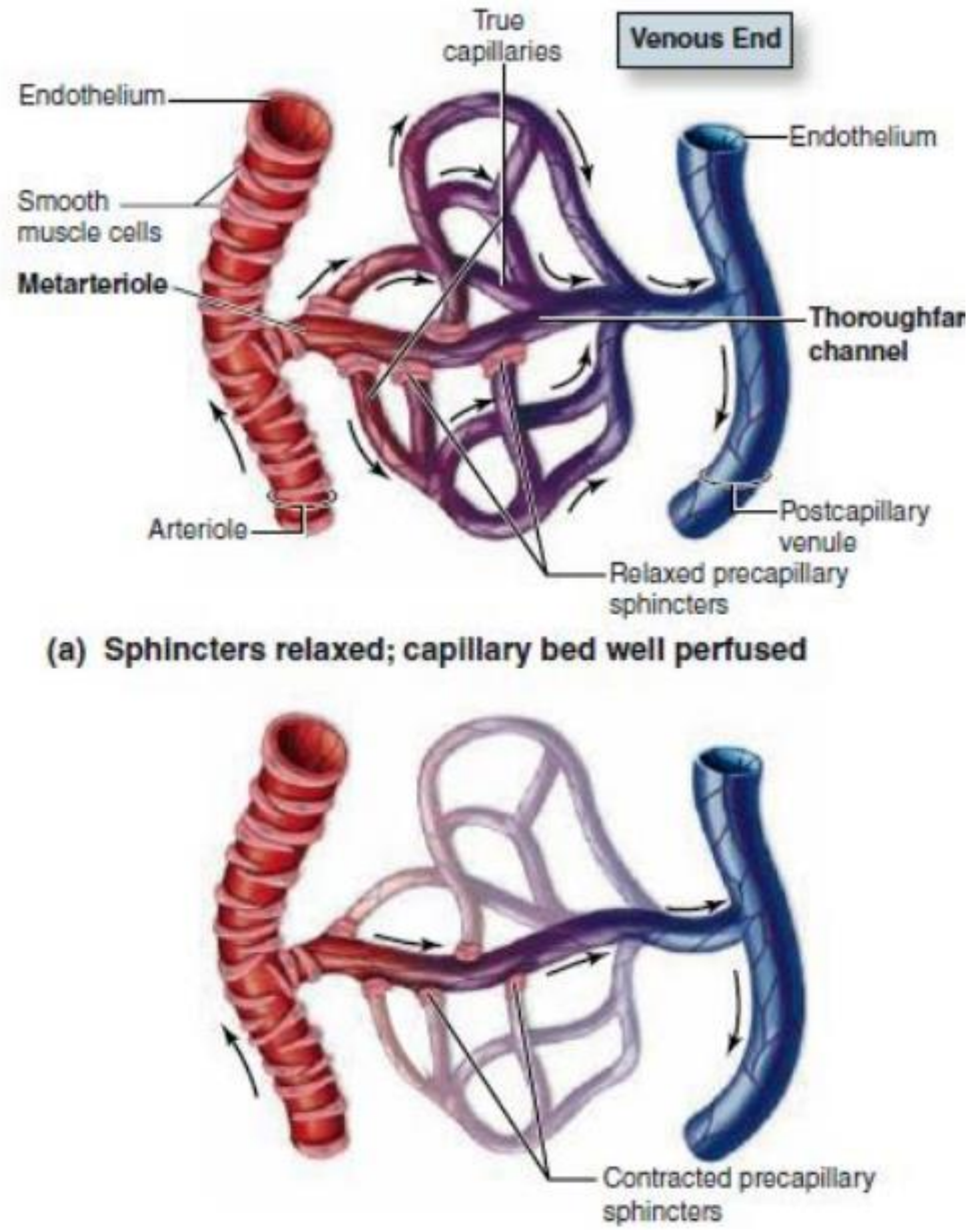
4) Capillaries: branches of the arteriole

*Function: permit and regulate metabolic exchange between blood and surrounding tissues.

*Capillary beds: network of capillaries whose overall shape and density conforms to that of the structure supplied. So tissues with high metabolic rates, such as the kidney, liver, and cardiac and skeletal muscles, have abundant capillaries; the opposite is true for tissues with low metabolic rates, such as smooth muscle and dense connective tissue.

Structure of capillary beds:

Capillary beds are supplied preferentially by one or more terminal arteriole branches called **metarterioles**, which are continuous with **thoroughfare channels** connected with the **post-capillary venules**. Capillaries branch from the metarterioles, which are encircled by scattered smooth muscle cells, and converge into the thoroughfare channels, which lack muscle. The metarteriole muscle cells act as precapillary sphincters that control blood flow into the capillaries. These sphincters contract and relax cyclically, with 5-10 cycles per minute, causing blood to pass through capillaries in a pulsatile manner. When the sphincters are closed, blood flows directly from the metarterioles and thoroughfare channels into post-capillary venules.



(a) Sphincters relaxed; capillary bed well perfused

Summary of this concept: to control the amount of blood reaching the tissue either by contracting or relaxing the muscles we have at the entrance of capillaries. These muscles are called the sphincter muscles which are smooth muscles.

So if you need more blood to the tissue (when you are running for example) sphincters will relax so blood will pass through the capillary bed as well as the thoroughfare channel, but when you need less blood, sphincters will contract and blood will only pass through the thoroughfare channel. Therefore, because of the cyclical opening and closing of the sphincters, most capillaries are essentially empty at any given time.

*Structure of capillaries: Capillaries are composed of the simple layer of endothelial cells rolled up as a tube surrounded by basement membrane. The average diameter of capillaries varies from 4 to 10 µm, which allows transit of blood cells only one at a time.

*There are 3 types of capillaries depending on the continuity of the endothelial cells and their basement membrane. These are **continuous, fenestrated and discontinuous**.

1- Continuous capillaries

have many tight, well-developed occluding junctions between slightly overlapping endothelial cells, which provide for continuity along the endothelium and well-regulated metabolic exchange across the cells. This is the most common type of capillary and is found in muscles, connective tissue, lungs, exocrine glands, and nervous tissue. Ultrastructural studies show numerous vesicles indicating transcytosis of macromolecules in both directions across the endothelial cell cytoplasm.

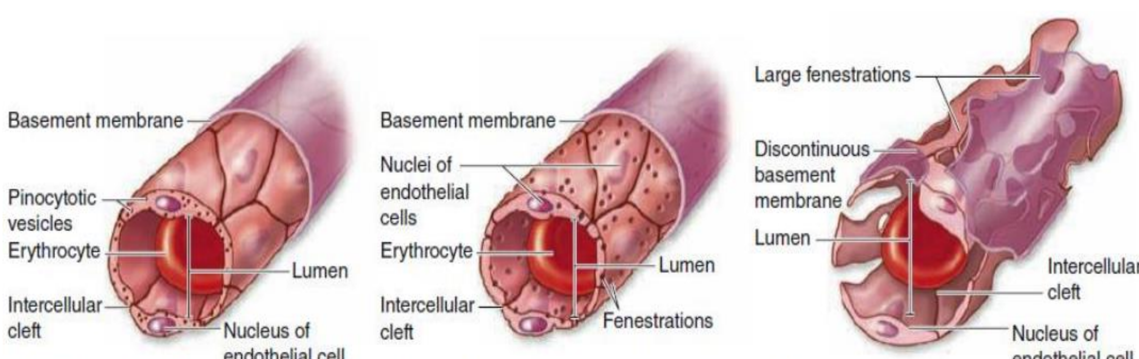
2- Fenestrated Capillaries:

these have a sieve-like structure that allows more extensive molecular exchange across the endothelium.

The endothelial cells are penetrated by numerous small circular openings or fenestrations (L. fenestra, perforation), approximately 80 nm in diameter. Some fenestrations are covered by very thin diaphragms of proteoglycans; others may represent membrane invaginations during transcytosis that temporarily involve both sides of the very thin cells. The basement membrane however, is continuous and covers the fenestrations. Fenestrated capillaries are found in organs with rapid interchange of substances between tissues and the blood, such as the kidneys, intestine, choroid plexus, and endocrine glands.

3- Discontinuous Capillaries: these are

commonly called **sinusoids** and they permit maximal exchange of macromolecules as well as allow easier movement of cells between tissues and blood. The endothelium here has large perforations without diaphragms and irregular intercellular clefts, forming a discontinuous layer with spaces between and through the cells. Unlike other capillaries sinusoids also have highly discontinuous basement membranes and much larger diameters, often 30-40 µm, which slows blood flow. Sinusoidal capillaries of this type are found in the liver, spleen, some endocrine organs, and bone marrow.



(a) Continuous capillary (b) Fenestrated capillary (c) Sinusoid

Good luck 0_0