

Circulatory System

The cardiovascular system provides a continuous circulatory system which is virtually closed. It permits blood vascular system to transport nutrients, oxygen, carbon dioxide, hormones, cells of immune defensive system to all parts of the body and remove the cellular products of metabolism. Responsible for gaseous exchange and temperature control of the body.

From the aorta, blood enters the arteries and arterioles. At the end, the arterioles are capillaries. The blood flows through the capillaries and enters the venous system.

The blood flows from the capillaries, to venules to veins to two largest veins, SVC and IVC.

Types of Circulation

- i. Systemic circulation.
- ii. Pulmonary circulation.
- iii. Portal circulation.
- iv. Lymphatic circulation (lymph from interstitial spaces between cells and veins.
- v. Circulations (others): CSF, perilymph and endocochlear fluids, ocular aqueous humor, synovial fluids and fluids of coelomic cavities.

THREE TUNICS OF BLOOD VESSELS

Tunica intima, tunica media and tunica adventitia.

Tunica Intima

Tunica intima has 3 layers from inside lumen to outside: Endothelium, subendothelium and internal elastic lamina.

Endothelium

Endothelium is the thin layer of flat cells that lines the inner surface of blood vessels forming an interface between circulating blood and the vessel wall. Cells of the endothelium are called endothelial cells or endotheliocytes.

It is only layer in the capillaries. Thereafter, addition of coats. Wide tile-like, curved to fit the curvature of blood vessel.

- i. Mononuclear, polygonal with sparse cytoplasm (squamous)
- ii. Endothelium serves major physiological roles.

Functions

- It provides smooth internal lining to the blood vessel and heart.
- It coated with glycocalyx which controls the transport across and contributes for non-thrombogenic properties of endothelium.
- It regulates the diffusion of substances.
- It secretes substances that provide vasodilatation and influences tone of smooth muscles.
- It produces clotting factors—controls coagulation.

Basic Structure of Arteries: Three concentric tunics

- i. Tunica intima (innermost)
- ii. Tunica media (middle)
- iii. Tunica adventitia (outermost)

Tunica intima

- i. Endothelium, mononuclear, polygonal cells on the basal lamina.

- ii. Subendothelium layer: Delicate fibroelastic connective tissue (CF, EF, smooth muscle and fibroblast cell)
- iii. Internal elastic lamina: Band of elastic fibers.

Tunica media

- Chiefly consists of smooth muscle arranged circularly, between are elastic and collagen fibers. Limited by external elastic lamina.
- Thickest in arteries, thin in veins, absent in capillaries.

Tunica adventitia

- i. Principally consists of connective tissue (CF, EF) run parallel to long axis of vessel.
- ii. Prevents undue stretching or distension of the artery.
- iii. It also contains vasa vasorum (supplies tunica adventitia and outer two-thirds of tunica media in case of arteries and all the tunicas in veins) and sympathetic nerves.

CLASSIFICATION OF ARTERIES

- i. Large arteries (elastic arteries)—conducting vessels, e.g. aorta and its branches.
- ii. Muscular arteries (medium sized arteries)—distributing vessels, with smooth muscles in tunica media.
- iii. Arterioles—resistance arteries.
- iv. Capillaries—exchange vessels.

1. Elastic arteries or conducting vessels (e.g. aorta, CCA, BrCT and SCA)

Tunica intima

- i. 20% of total thickness. Endothelial cells flat, 1–2 μm thickness
- ii. Subendothelial layer well developed (CF, EF, a few smooth muscle, fibroblast and macrophages—longitudinal orientation).
- iii. Internal elastic lamina—1 μm . Thickness, difficult to identify.

Tunica media

It characterized numerous distinct elastic lamina or membrane 40–60 in number arranged concentrically and fenestrated. Also presents are CF, and smooth muscle + fibroblast cells. Each elastic lamina + adjacent intralaminar zone together is known as laminar unit.

Human aorta has 52 laminar unit. 11 um thickness. 60 EL → thoracic aorta, 30 EL—abdominal aorta. Number of elastic Lamina increases until 35 years.

At 50 years show degeneration replaced by collagen fibers. Limited by outer: external elastic lamina.

Tunica adventitia

It is thin not well developed. Consists of CF, EF and a few smooth muscles. Nutritive vessels vasovasorum, nerves bundles and lymphatic capillaries are present.

Tunica media of abdominal aorta prone for degenerative changes—aneurysm.

2. Medium sized arteries or muscular or distributing arteries

Most of arteries are muscular arteries. Wall is thick due to large amount of smooth muscles in tunica media. Distributing arteries because they distribute to different organs and regulate blood supply according to functional needs (contraction and relaxation of smooth muscles in tunica media), e.g. axillary, radial, femoral and popliteal arteries, etc.

Tunica intima—exhibits three definite layers

- i. Endothelial flat cells
- ii. Subendothelial layer delicates EF, CF, a few fibroblasts.
- iii. Internal elastic lamina very prominent, thick fenestrated band interwoven elastic fiber (folds—smooth muscles, tunica media seen only in postmortem).

Tunica media

Exclusively circular or helical dispersed smooth muscles cells (40 layers).

Between are small amount of connective tissue (CF, EF RF).
External elastic lamina (marked).

Tunica adventitia

Often thick as tunica media. Dense irregular connective tissue (CF, EF) helically or longitudinal blending with neighboring tissue. Tiny vasa vasorum and nerves are present.

3. Arterioles—resistance vessels

Tunica intima

Only endothelium, no sub-endothelial layer. IEL—network of elastic fibers.

Tunica media

3–4 layers of thin circular smooth muscle, limited by EEL.

Tunica adventitia

Thick as tunica media contains CF, EF, arranged longitudinal, emerge surrounding tissues. Arterioles have relatively thick wall and narrow lumen. Control distribution of blood to capillary bed by vasoconstriction and vasodilatation. Their are prime controller of systemic blood pressure. Not involved in exchange. Regulated by sympathetic nerves.

4. Capillaries

Latin capillaries, from capillus means hair like, fine and slender. There are thin walled endothelial tubes, only one cell layer thick. Connect arteries with veins.

Terminal arterioles continue with capillary plexuses which vary tissue to tissue.

Capillaries are parts of microcirculation, these microvessels measuring (luminal diameter—8–12 um) slightly wider than RBCs.

Wall of capillaries

1. Single layer of endothelial cells, on basal lamina coated with glycoprotein.

2. Surrounded by thin delicate collagen fiber, reticular fiber.
3. Accompanied by pericytes, elongated undifferentiated cell.

Classification of capillaries

1. *Continuous capillary*

Continuous capillary (type I)—the individual endothelial cell lines the capillary lumen enough to encircle the entire lumen, e.g. muscles, lung, brain and skin.

2. *Fenestrated capillary*

Fenestrated capillary (type II)—the endothelial cell cytoplasm on each side of nucleus is perforated with pores or fenestrations closed by diaphragm, e.g. intestinal mucosa, endocrines and glomerular capillaries.

3. *Sinusoid (capillary)*

The capillaries endothelial cells exhibit some wide intercellular gaps which permit fluid exchange between plasma and the tissue fluid, e.g. liver, bone marrow, endocrine glands.

5. Medium sized vein femoral and axillary vein

Tunica intima

Endothelium, subendothelial and IEL are ill defined.

Tunica media

Thin compared to artery, small smooth muscle circularly. Tunica media well in lower limbs. Cerebral dural venous sinus—no smooth muscle.

Tunica adventitia

Well developed. Forms the bulk of the wall with longitudinal CF and a few smooth muscle. Vasa vasorum—supply all the three tunics and nerves.

6. Large vein (e.g. SVC, IVC and portal vein)

Tunica intima

Endothelial layer, subendothelial and IEL are ill defined.

Tunica media

Poorly developed with a few smooth muscles.

Tunica adventitia

Thickest and has 3 zones with vasa vasorum and nerves

- i. Dense fibroelastic connective tissue—spirally.
- ii. Middle-smooth muscle—longitudinal.
- iii. Outer zone—network of collagen fibers.

Applied Histology

Vasculitis is a feature inflammation of the blood vessels. Blood vessel inflammation is a painful condition that can have many possible causes.

Autoimmune disorders, tumors, leukemia, or certain medications have all been known to lead to inflamed veins and arteries.

Vasculitis, inflammation of veins (phlebitis) and arteries (arteritis).