Abstract

By the end of this section, you will be able to:

- Compare and contrast the three tunics that make up the walls of most blood vessels
- Distinguish between elastic arteries, muscular arteries, and arterioles on the basis of structure, location, and function
- Describe the basic structure of a capillary bed, from the supplying metarteriole to the venule into which it drains
- Explain the structure and function of venous valves in the large veins of the extremities

Blood is carried through the body via blood vessels. An artery is a blood vessel that carries blood away from the heart, where it branches into ever-smaller vessels. Eventually, the smallest arteries, vessels called arterioles, further branch into tiny capillaries, where nutrients and wastes are exchanged, and then combine with other vessels that exit capillaries to form venules, small blood vessels that carry blood to a vein, a larger blood vessel that returns blood to the heart.

Arteries and veins transport blood in two distinct circuits: the systemic circuit and the pulmonary circuit (Figure 1 (Cardiovascular Circulation)). Systemic arteries provide blood rich in oxygen to the body’s tissues. The blood returned to the heart through systemic veins has less oxygen, since much of the oxygen carried by the arteries has been delivered to the cells. In contrast, in the pulmonary circuit, arteries carry blood low in oxygen exclusively to the lungs for gas exchange. Pulmonary veins then return freshly oxygenated blood from the lungs to the heart to be pumped back out into systemic circulation. Although arteries and veins differ structurally and functionally, they share certain features.
Cardiovascular Circulation

Figure 1: The pulmonary circuit moves blood from the right side of the heart to the lungs and back to the heart. The systemic circuit moves blood from the left side of the heart to the head and body and returns it to the right side of the heart to repeat the cycle. The arrows indicate the direction of blood flow, and the colors show the relative levels of oxygen concentration.

1 Shared Structures

Different types of blood vessels vary slightly in their structures, but they share the same general features. Arteries and arterioles have thicker walls than veins and venules because they are closer to the heart and receive blood that is surging at a far greater pressure (Figure 2 (Structure of Blood Vessels)). Each type of vessel has a lumen—a hollow passageway through which blood flows. Arteries have smaller lumens than veins, a characteristic that helps to maintain the pressure of blood moving through the system. In addition, many veins of the body, particularly those of the limbs, contain valves that assist the unidirectional flow of blood toward the heart. This is critical because blood flow becomes sluggish in the extremities, as a result of the lower pressure and the effects of gravity.
Structure of Blood Vessels

Figure 2: (a) Arteries and (b) veins share the same general features, but the walls of arteries are much thicker because of the higher pressure of the blood that flows through them. (c) A micrograph shows the relative differences in thickness. LM × 160. (Micrograph provided by the Regents of the University of Michigan Medical School ©2012)
Layers of the Blood Vessels

There are 3 layers called tunics in both arteries and veins. The three layers from the inside to the outside are called the tunica intima, the tunica media and outermost layer called the tunica externa (or the tunica adventitia).

1.1 Tunica Intima

The tunica intima (also called the tunica interna) is composed of epithelial and connective tissue layers. Lining the tunica intima is the specialized simple squamous epithelium called the endothelium, which is continuous throughout the entire vascular system, including the lining of the chambers of the heart. Damage to this endothelial lining and exposure of blood to the collagenous fibers beneath is one of the primary causes of clot formation.

1.2 Tunica Media

The tunica media is the substantial middle layer of the vessel wall (see Figure 2 (Structure of Blood Vessels)). It is generally the thickest layer in arteries, and it is much thicker in arteries than it is in veins. The tunica media consists of layers of smooth muscle supported by connective tissue that is primarily made up of elastic fibers. Specifically in arteries, vasoconstriction decreases blood flow as the smooth muscle in the walls of the tunica media contracts, making the lumen narrower and increasing blood pressure. Similarly, vasodilation increases blood flow as the smooth muscle relaxes, allowing the lumen to widen and blood pressure to drop.

1.3 Tunica Externa

The outer tunic, the tunica externa (also called the tunica adventitia), is a substantial sheath of connective tissue composed primarily of collagenous fibers. The outer layers of the tunica externa are not distinct but rather blend with the surrounding connective tissue outside the vessel, helping to hold the vessel in relative position.

2 Arteries

An artery is a blood vessel that conducts blood away from the heart. All arteries have relatively thick walls that can withstand the high pressure of blood ejected from the heart. However, those close to the heart have the thickest walls, containing a high percentage of elastic fibers in all three of their tunics. This type of artery is known as an elastic artery (). The elastic recoil of the vascular wall helps to maintain the pressure changes that drives the blood through the arterial system. Farther from the heart, where the surge of blood has lessened, the type of vessel found is called a muscular artery. Fortunately, because the blood pressure has eased by the time it reaches these more distant vessels, elasticity has become less important.

3 Arterioles

An arteriole is a very small artery that leads to a capillary. Arterioles have the same three tunics as the larger vessels, but the thickness of each is greatly diminished. The critical endothelial lining of the tunica intima is intact. The tunica media is restricted to one or two smooth muscle cell layers in thickness. The tunica externa remains but is very thin (see ).

4 Capillaries

A capillary is a microscopic vessel that supplies blood to the tissues themselves. Exchange of gases and other substances between the blood and the surrounding cells and their tissue fluid (interstitial fluid)occurs only in the capillaries. The smallest capillaries are just barely wide enough for an red blood cell to squeeze
through. The **precapillary sphincters**, tightly regulate the flow of blood to the capillaries. Their function is critical: If all of the capillary beds in the body were to open simultaneously, they would collectively hold every drop of blood in the body and there would be none in the arteries, arterioles, venules, veins, or the heart itself.

### 5 Metarterioles and Capillary Beds

A **metarteriole** is a type of vessel that has structural characteristics of both an arteriole and a capillary. Slightly larger than the typical capillary, the smooth muscle of the tunica media of the metarteriole is not continuous but forms rings of smooth muscle (sphincters) prior to the entrance to the capillaries. Each metarteriole arises from a terminal arteriole and branches to supply blood to a **capillary bed** that may consist of 10–100 capillaries.

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**Figure 3:** In a capillary bed, arterioles give rise to metarterioles. Precapillary sphincters located at the junction of a metarteriole with a capillary regulate blood flow. A thoroughfare channel connects the metarteriole to a venule. An arteriovenous anastomosis, which directly connects the arteriole with the venule, is shown at the bottom.

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### 6 Veins and Venules

A **venule** is an extremely small vein, which join with multiple capillaries exiting from a capillary bed. Multiple venules join to form veins. A **vein** is a blood vessel that conducts blood toward the heart. Compared
to arteries, veins are thin-walled vessels with large and irregular lumens (see ). Because they are low-pressure vessels, larger veins are commonly equipped with valves that promote the unidirectional flow of blood toward the heart and prevent backflow toward the capillaries caused by the pull of gravity. compares the features of arteries and veins.

7 Chapter Review

Blood pumped by the heart flows through a series of vessels known as arteries, arterioles, capillaries, venules, and veins before returning to the heart. Arteries transport blood away from the heart and branch into smaller vessels, forming arterioles. Arterioles distribute blood to capillary beds, the sites of exchange with the body tissues. Capillaries lead back to small vessels known as venules that flow into the larger veins and eventually back to the heart.

The arterial system is a relatively high-pressure system, so arteries have thick walls that appear round in cross section. The venous system is a lower-pressure system, containing veins that have larger lumens and thinner walls. They often appear flattened. Arteries, arterioles, venules, and veins are composed of three tunics known as the tunica intima, tunica media, and tunica externa. Capillaries have only a tunica intima layer. The tunica intima is a thin layer composed of a simple squamous epithelium known as endothelium and a small amount of connective tissue. The tunica media is a thicker area composed of variable amounts of smooth muscle and connective tissue. It is the thickest layer in all but the largest arteries. The tunica externa is primarily a layer of connective tissue, although in veins, it also contains some smooth muscle. Blood flow through vessels can be dramatically influenced by vasoconstriction and vasodilation in their walls.

Glossary

Definition 1: arteriole
(also, resistance vessel) very small artery that leads to a capillary

Definition 2: arteriovenous anastomosis
short vessel connecting an arteriole directly to a venule and bypassing the capillary beds

Definition 3: artery
blood vessel that conducts blood away from the heart; may be a conducting or distributing vessel

Definition 4: capacitance
ability of a vein to distend and store blood

Definition 5: capacitance vessels
veins

Definition 6: capillary
smallest of blood vessels where physical exchange occurs between the blood and tissue cells surrounded by interstitial fluid

Definition 7: capillary bed
network of 10-100 capillaries connecting arterioles to venules

Definition 8: continuous capillary
most common type of capillary, found in virtually all tissues except epithelia and cartilage; contains very small gaps in the endothelial lining that permit exchange

Definition 9: elastic artery
(also, conducting artery) artery with abundant elastic fibers located closer to the heart, which maintains the pressure gradient and conducts blood to smaller branches

Definition 10: external elastic membrane
membrane composed of elastic fibers that separates the tunica media from the tunica externa; seen in larger arteries

http://m.cnx.org/content/m49689/1.1/
Definition 11: fenestrated capillary
type of capillary with pores or fenestrations in the endothelium that allow for rapid passage of
certain small materials

Definition 12: internal elastic membrane
membrane composed of elastic fibers that separates the tunica intima from the tunica media; seen
in larger arteries

Definition 13: lumen
interior of a tubular structure such as a blood vessel or a portion of the alimentary canal through
which blood, chyme, or other substances travel

Definition 14: metarteriole
short vessel arising from a terminal arteriole that branches to supply a capillary bed

Definition 15: microcirculation
blood flow through the capillaries

Definition 16: muscular artery
(also, distributing artery) artery with abundant smooth muscle in the tunica media that branches
to distribute blood to the arteriole network

Definition 17: nervi vasorum
small nerve fibers found in arteries and veins that trigger contraction of the smooth muscle in their
walls

Definition 18: perfusion
distribution of blood into the capillaries so the tissues can be supplied

Definition 19: precapillary sphincters
circular rings of smooth muscle that surround the entrance to a capillary and regulate blood flow
into that capillary

Definition 20: sinusoid capillary
rarest type of capillary, which has extremely large intercellular gaps in the basement membrane in
addition to clefts and fenestrations; found in areas such as the bone marrow and liver where passage
of large molecules occurs

Definition 21: thoroughfare channel
continuation of the metarteriole that enables blood to bypass a capillary bed and flow directly into
a venule, creating a vascular shunt

Definition 22: tunica externa
(also, tunica adventitia) outermost layer or tunic of a vessel (except capillaries)

Definition 23: tunica intima
(also, tunica interna) innermost lining or tunic of a vessel

Definition 24: tunica media
middle layer or tunic of a vessel (except capillaries)

Definition 25: vasa vasorum
small blood vessels located within the walls or tunics of larger vessels that supply nourishment to
and remove wastes from the cells of the vessels

Definition 26: vascular shunt
continuation of the metarteriole and thoroughfare channel that allows blood to bypass the capillary
beds to flow directly from the arterial to the venous circulation

Definition 27: vasoconstriction
constriction of the smooth muscle of a blood vessel, resulting in a decreased vascular diameter
Definition 28: vasodilation
relaxation of the smooth muscle in the wall of a blood vessel, resulting in an increased vascular
diameter

Definition 29: vasomotion
irregular, pulsating flow of blood through capillaries and related structures

Definition 30: vein
blood vessel that conducts blood toward the heart

Definition 31: venous reserve
volume of blood contained within systemic veins in the integument, bone marrow, and liver that
can be returned to the heart for circulation, if needed

Definition 32: venule
small vessel leading from the capillaries to veins