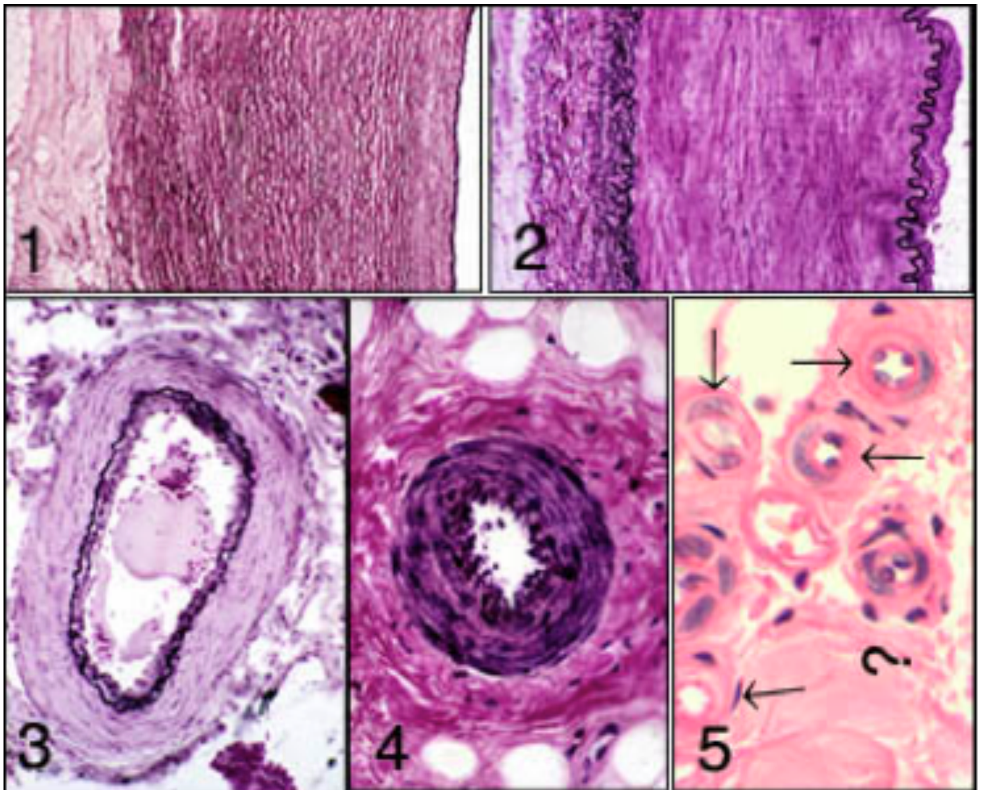
Arteries



1. A region through the wall of an elastic (conducting) artery.
2. A portion of a muscular (distributing) artery.
3. A small artery.
4. A small artery of lesser caliber.
5. Several arterioles (arrows).

Although blood vessels differ in size, distribution, and function, structurally they share many common features. As in the heart, the walls of blood vessels consist of three major coats or tunics. Differences in the appearance and functions of the various parts of the circulatory system are reflected by structural changes in these tunics or by reduction and even omission of some of the layers. From the lumen outward, the wall of a blood vessel consists of a tunica intima, tunica media, and tunica adventitia.

The *tunica intima* corresponds to and is continuous with the endocardium of the heart. It consists of an endothelium of flattened squamous cells resting on a basal lamina and is supported by a subendothelial connective tissue.

The *tunica media* is the equivalent of the myocardium of the heart and is the layer most variable both in size and structure. Depending on the function of the vessel, this layer contains variable amounts of smooth muscle and elastic tissue.

The *tunica adventitia* also varies in thickness in different parts of the vascular circuit.

It consists mainly of collagenous connective tissue and corresponds to the epicardium of the heart, but it lacks mesothelial cells.

As *arteries* course away from the heart they undergo successive divisions to provide numerous branches whose calibers progressively decrease. The changes in size and the corresponding changes in structure of the vessel wall are continuous, but three classes of arteries can be distinguished: large elastic or conducting arteries, medium-sized muscular or distributing arteries, and small arteries and arterioles. A characteristic feature of the entire arterial side of the blood vasculature system is the prominence of smooth muscle in the tunica media.

Elastic or Conducting Arteries

The aorta is the main conducting artery, but others in this class are the common iliacs and pulmonary, brachiocephalic, subclavian, and common carotid arteries. A major feature of this type of artery is the width of the lumen, which, by comparison, makes the wall of the vessel appear thin.

The tunica intima is relatively thick and is lined by a single layer of flattened, polygonal endothelial cells that rest on a complete basal lamina. Adjacent endothelial cells may be interdigitated or overlap and are extensively linked by occluding and communicating (gap) junctions. The cells contain the usual organelles, but these are few in number. Peculiar membrane-bound, rod-shaped granules, consisting of several tubules embedded in an amorphous matrix, are present and have been shown to contain a factor (VIII) associated with blood coagulation that is synthesized by these cells and released into the blood. A proteoglycan layer, the endothelial coat, covers the luminal surface of the cell membrane. On the basal surface, the endothelial cells are separated from the basal lamina by an amorphous matrix. Numerous invaginations or caveolae are present at the luminal and basal surfaces of the plasmalemma, and the cytoplasm contains many small vesicles 50 to 70 nm in diameter. These transcytotic vesicles are thought to form at one surface, detach, and cross to the opposite side, where they fuse with the plasmalemma to discharge their contents. In humans, about one-fourth of the total thickness of the intima is formed by the subendothelial layer, a layer of loose connective tissue that contains elastic fibers and a few smooth muscle cells. The tunica media is the thickest layer and consists largely of elastic tissue that forms 50 to 70 concentric, fenestrated sheets or elastic laminae, each about 2 or 3 µm thick and spaced 5 to 20 µm apart. Successive laminae are connected by elastic fibers. In the spaces between the laminae are thin layers of connective tissue that contain collagen fibers and smooth muscle cells arranged circumferentially. The smooth muscle cells are flattened, irregular, and branched and are bound to adjacent elastic laminae by elastic microfibrils and reticular fibers. An appreciable amount of amorphous ground substance also is present. Smooth muscle cells are the only cells present in the media of elastic arteries and synthesize and maintain the elastic fibers and collagen. Elastic arteries are those nearest the heart and, because of the great content of elastic tissue, are expandable. As blood is pumped from the heart during its contraction, the walls of elastic arteries expand; when the heart relaxes, the elastic recoil of these vessels serves as an auxiliary pumping mechanism to force blood onward between beats. The tunica adventitia is relatively thin and contains bundles of collagen fibers (type 1) and a few elastic fibers, both of which have a loose, helical arrangement about the vessel. Fibroblasts, mast cells, and rare longitudinally oriented smooth muscle cells also are present. The tunica adventitia gradually blends into the surrounding loose connective tissue and functions to anchor the vessel to adjacent structures. The walls of large arteries are too thick to be nourished only by diffusion from the lumen. Consequently, these vessels have their own small arteries, the vasa vasorum, that may arise as branches of the main vessel itself or derive from neighboring vessels. They form a plexus in the tunica adventitia and generally do not penetrate deeply into the media.

Muscular or Distributing Arteries

The muscular or distributing arteries are the largest class, and except for the elastic arteries, the named arteries of gross anatomy fall into this category. All the small branches that originate from elastic trunks are muscular arteries, and the transition is relatively abrupt, occurring at the openings of the branching arteries. Compared with the luminal diameter, the walls of these arteries are thick and make up over one-fourth of the cross-sectional diameter. The thickness of the wall is due mainly to the large amount of smooth muscle in the media, which, by contraction and relaxation, helps to regulate the blood supply to organs and tissues. The general organization of these vessels is similar to that of elastic arteries, but the proportion of cells and fibers differs. The tunica intima consists of an endothelium, a subendothelial layer, and an internal elastic lamina. The endothelium and subendothelial layers are similar to those of elastic arteries, but as the size of the vessel decreases, the subendothelial layer becomes thinner. It contains fine collagen fibers, a few elastic fibers, and scattered smooth muscle cells that are longitudinal in orientation. The internal elastic lamina is a fenestrated sheet of elastin that forms a prominent, scalloped boundary between the tunica media and the tunica intima. The basal surface of the endothelial cells sends slender processes through discontinuities in the elastic lamina to make contact with cells in the tunica media.

The tunica media is the thickest coat and consists mainly of smooth muscle cells arranged in concentric, helical layers. The number of layers varies from 3 to 4 in smaller arteries to 10 to 40 in the large muscular arteries. The muscle cells are surrounded by basal laminae and communicate with each other by gap junctions. Reticular fibers and small bundles of collagen fibers interspersed with elastic fibers are present between the layers of smooth muscle. The number and distribution of elastic fibers correlate with the caliber of the artery. In the smaller vessels elastic fibers are scattered between the muscle cells, whereas in larger arteries the elastic tissue forms circular, loose networks. At the junction of the tunica media and the tunica adventitia, the elastic tissue forms a second prominent fenestrated membrane called the external elastic lamina.

The tunica adventitia is prominent in muscular arteries and in some vessels may be as thick as the media. It consists of collagen and elastic fibers that are longitudinal in orientation. This coat continues into the surrounding loose connective tissue with no clear line of demarcation.

Muscular arteries are highly contractile with the degree of contraction controlled primarily by the autonomic nervous system and factors produced by endothelial cells. For example, adrenergic sympathetic innervation of smooth muscle cells in the media of these vessels results in their contraction and vasoconstriction of the vessel.

Small Arteries and Arterioles

Small arteries and arterioles differ from large muscular arteries only in size and the thickness of their walls. The distinction between small arteries and arterioles is mainly one of definition: Arterioles are those small arteries with a diameter less than 250 to 300 μm and in which the media contains only one or two layers of smooth muscle cells. In the progression from distributing artery to arteriole, the subendothelial connective tissue progressively decreases until in arterioles, a subendothelial layer is lacking and the tunica intima consists only of endothelium and a fenestrated internal elastic lamina. The endothelial cells are joined by occluding junctions. Basal processes make contact with smooth muscle cells through the fenestrations in the elastic lamina. The thin basal lamina becomes indistinct in the smallest arterioles. The layers of smooth muscle cells of the media progressively decrease in number, and at a diameter of about 30 μm, the muscle coat of arterioles consists of a single layer of circumferentially oriented cells. The internal elastic membrane is thin and disappears in terminal arterioles; there is no definite external elastic lamina. Tunica adventitia also decreases in thickness, becoming extremely thin in the smallest arterioles. Compared with the luminal size, the walls of arterioles are thick. Because of the smooth muscle in the media, arterioles control the flow of blood to the capillary beds they feed and are the primary regulators of blood pressure. Because these vessels contain highly oxygenated blood, they tend to shunt the blood flow towards the capillary beds in which the tissues have low oxygen. Arterioles are quite responsive to vascular stimuli and as a consequence are major contributors to vascular resistance.

Metarterioles

Metarterioles are intermediate between capillaries and arterioles and regulate the flow of blood through capillary beds. They also are called capillary sphincter areas or precapillary arterioles. Although poorly defined morphologically, their lumina generally are wider than those of the capillaries they serve, and circularly arranged smooth muscle cells are scattered in their walls. Here, individual smooth muscle cells spaced a short distance apart, completely encircle the endothelial tube and form a surrounding corkscrew configuration.