The Cardiovascular system: Blood vessels

(Chapter 21)

blood vessel structure and function

three major types
1. arteries
2. capillaries
3. veins

structure of blood vessel walls

three layers of all but the smallest vessels
1. tunica intima
   1. is innermost layer
   2. in contact with the blood
   3. contains the endothelium
   4. contains a subendothelial layer of connective tissue which supports the endothelium
   5. contains internal elastic membrane
      thick layer of elastic fibers

2. tunica media
   1. middle layer
   2. mostly circularly arranged smooth muscle
   3. is innervated by vasomotor nerve fibers that regulate the activity of the smooth muscle
      muscle fibers may induce vasoconstriction or vasodilation
   4. also contains external elastic membrane
      thin layer of elastic fibers

3. tunica externa or adventitia
   1. outermost layer
   2. mostly collagen fibers in arteries
      mainly elastic fibers and smooth muscle in veins
3. also contains nerve fibers headed to the media

both the tunica media and adventitia of larger to medium size vessels contain tiny blood vessels called vasa vasorum which nourish the outer layers of the vessel

**Arterial system:**
transport blood away from the heart
systemic arteries carry oxygenated blood
pulmonary carries deoxygenated blood

**four types of arteries**
1. conducting (elastic) arteries
2. distributing (muscular) arteries
3. resistance arteries (arterioles)
4. metarterioles
   connect arterioles with capillaries

**conducting or elastic arteries**
1. large thick-walled
2. is the aorta and major branches
3. have large lumen size to serve as a low resistance pathway to conduct blood from the heart
4. contain more elastin then other types
   is in all three tunics most in media
   allows the large vessels to withstand and smooth out large pressure fluctuations when heart contracts and relaxes
5. have a lot of smooth muscle but is inactive so are just simple elastic tubes

**distributing or muscular arteries**
1. are the arteries that deliver blood to specific organs called distribution arteries
2. are most of the named arteries
3. size is from finger to pencil lead
4. proportional have the thickest media layer
   are more active in vasoconstriction thus very important in controlling perfusion and blood pressure

**resistance or arterioles**
1. smallest of the arteries
2. larger arterioles have all three tunics
   smaller ones are basically a single layer of smooth muscle cells spiraling around the endothelial lining
3. vasoconstriction and relaxation of the arterioles controls the blood flow into the capillary beds change the resistance thus arterioles are called resistance vessels

**metarterioles**
connect arterioles with capillaries

capillaries
1. are the smallest vessels
2. consist of just a thin tunica intima
3. the smallest capillaries are just a tube of endothelial cells with some basement membrane
4. diameter is 8-10 microns just enough to let rbc pass through are 1mm long
5. most tissues have a rich supply of capillaries provide direct access to nearly every cell in the body
6. function is to provide exchanges of gases, nutrients, hormones, etc. between blood and interstitial fluid

types of capillaries
1. **continuous capillaries**
   1. endothelial cells provides an uninterrupted lining
   2. adjacent cells are joined laterally by tight junctions which are incomplete leaving gaps called **intercellular cleft**
   clefts allow limited passage of fluids and small solutes
   3. the endothelial cells contain numerous small pinocytotic vesicles that are important in transport of fluids across the endothelial cells
   4. in the brain and thymus the capillary type is continuous capillaries but there are no intercellular clefts this results in the formation of the blood brain barrier and blood thymus barrier
   5. are also abundant in the skin and the muscles

2. **fenestrated capillaries**
   1. similar to continuous but some of the endothelial cells have oval pores or fenestrations
the fenestration pores are covered by a
delicate membrane

thus are more permeable to fluids and small
solutes

2. are found where absorption and filtration is
important

small intestines
endocrine organs
kidneys
choroids plexus of brain

3. sinusoids

1. are fenestrated capillaries in which there are cells
missing
allow large molecules and cells to pass into and
out off the blood stream

2. are found in
liver
bone marrow
lymphoid tissue
some endocrine organs

capillary beds

a single metarteriole gives rise to dozens of capillaries
so capillaries form interwoven networks
several arteries may converge to form a single
metarteriole

insures that if one is blocked the
capillary bed will get blood

from metarteriole true capillaries arise while the metarteriole
pass directly into the thoroughfare channel on to the post
capillary venules

entrance of true capillaries are surrounded by a precapillary
sphincter

this regulates blood flow through the true
capillaries

if closed blood flows into thoroughfare channel
two third of capillaries are closed at
any time
regulation is via vasomotor nerve fibers (ANS) and local chemical needs (O2 and CO2, pH)

venous system

smallest venules are the **post capillary venules**
formed when capillaries unite

endothelium around a few fibroblasts
are extremely porous
fluid and wbc easily move out

venules

average diameter is 20 um
smaller venules lack tunica media
the larger venules have thin tunica media and a thin tunica adventitia

small veins

formed from the convergence of venules which converge to form

medium veins

which converge to form even fewer
range form 2 to 9 mm

have very thin tunica media with few smooth muscle cells
thickest layer is the tunica adventitia

large veins

all have the three tunica but the layers are thinner then in corresponding arteries
veins have lower blood pressure
also have larger lumen

tunica adventitia is the more dominate layer in veins

distribution of blood

due to the large lumen size veins can hold lots of blood
60-70% of total blood is on the venous side

thus called **capacitance vessels** or blood reservoirs
During massive blood loss, sympathetic stimulation constricts the smooth muscle, forcing blood from the venous side towards the arterial side to help maintain blood pressure and cardiac output.

**Venous valves**

Medium and large veins have venous valves that prevent blood from flowing backward so helps move blood to heart. Are folds of the tunica intima. Valves most abundant in limbs. Valves that are incompetent are called varicose veins. Hemorrhoids are varicose veins of the anus.

**Circulatory routes**

1. **Simple route**
   - Artery → Capillary → Vein

2. **Portal system**
   - Group of vessels connecting one capillary bed in one organ to second capillary bed in second organ.

   Hepatic portal system, renal portal system, and hypothalamic-anterior pituitary portal system.

Ex. Hepatic portal system - series of veins that carry venous blood from capillaries of digestive organs, pancreas & spleen to capillaries in the liver. Some nutrients such as glucose, fatty acids & amino acids are removed in the liver or modified for cell use. Some harmful substances are detoxed in liver. Why put a portal system here?

Hepatic portal vessels in humans (pp. 791-792)

1. **Superior mesenteric vein** - Drains small intestine, ascending colon & superior curvature of stomach (left gastroepiploic vein)
2. **Inferior mesenteric vein** - Drains descending & sigmoid colon, merges with pancreatic vein & splenic vein, then merges with superior mesenteric vein.
3. **Right & left gastric veins** - Drains inferior curvature of stomach.
4. **Cystic vein** - Drains gall bladder.

5. Above 4 veins merge to form Hepatic portal vein - HPV which enters liver, carries deoxygenated blood into liver sinusoids.

**Hepatic arteries** carry oxygenated blood to liver.
Hepatic veins carry both sources of blood from liver to inferior vena cava

3. **anastomosis**
   point where two vessels merge

**types of anastomosis**

1. **arterial** - arteries branch & rejoin by communicating branches forming collateral circulation that circumvents local interruptions of blood flow

2. **venous** - direct attachment between two veins provide alternate drainage routes for organs are most common

3. **arteriovenous** - flow from artery directly into vein bypassing capillaries forms shunts, reduces heat loss in peripheral appendages thoroughfare channel of capillary bed is example