The Cardiovascular System: Blood Vessels and Hemodynamics

- Structure and function of blood vessels
- Major circulatory routes
Anatomy of Blood Vessels

• Closed system of tubes that carries blood
• Arteries carry blood from heart to tissues
  – elastic arteries
  – muscular arteries
  – arterioles
• Capillaries are thin enough to allow exchange
• Venules merge to form veins that bring blood back to the heart
• Vasa vasorum is vessels in walls of large vessel
Arteries

• Tunica interna (intima)
  – simple squamous epithelium known as endothelium
  – basement membrane
  – internal elastic lamina

• Tunica media
  – circular smooth muscle & elastic fibers

• Tunica externa
  – elastic & collagen fibers
Sympathetic Innervation

- Vascular smooth muscle is innervated by sympathetic nervous system
  - increase in stimulation causes muscle contraction or vasoconstriction
    - decreases diameter of vessel
  - decrease in stimulation or presence of certain chemicals causes vasodilation
    - increases diameter of vessel
Elastic Arteries

- Largest-diameter arteries have lot of elastic fibers in tunica media
- Help propel blood onward despite ventricular relaxation (stretch and recoil)
Muscular Arteries

• Medium-sized arteries with more muscle than elastic fibers in tunica media
• Capable of greater vasoconstriction and vasodilation to adjust rate of flow
  – walls are relatively thick
Arterioles

• Small arteries delivering blood to capillaries
  – tunica media containing few layers of muscle
• Metarterioles form branches into capillary bed
Capillaries form Microcirculation

- Microscopic vessels that connect arterioles to venules
- Found near every cell in the body but more extensive in highly active tissue (muscles, liver, kidneys & brain)
  - entire capillary bed fills with blood when tissue is active
  - lacking in epithelia, cornea and lens of eye & cartilage
- Function is exchange of nutrients & wastes between blood and tissue fluid
- Structure is single layer of simple squamous epithelium and its basement membrane
Types of Capillaries

- Continuous capillaries
  - gaps between neighboring cells
  - muscle and lungs
- Fenestrated capillaries
  - plasma membranes have many holes
  - kidneys, small intestine & endocrine glands
- Sinusoids
  - very large fenestrations
  - incomplete basement membrane
  - liver, bone marrow, & spleen
Capillary Exchange

• Movement of materials in & out of a capillary
  – diffusion (most important method)
    • substances move down concentration gradient
    • all plasma solutes except large proteins pass freely across
      – through lipid bilayer, fenestrations or gaps between cells
      – blood brain barrier does not allow diffusion of water-soluble
        materials (nonfenestrated epithelium with tight junctions)
  – transcytosis
    • passage of material across endothelium in tiny vesicles by
      endocytosis and exocytosis
(d) Transverse section through an artery

(e) Red blood cells passing through a capillary
Venules

- Small veins collecting blood from capillaries
- Tunica media contains only a few smooth muscle cells & scattered fibroblasts
Veins

• Proportionally thinner walls than same diameter artery
  – tunica media less muscle
  – lack external & internal elastic lamina

• Still adaptable to variations in volume & pressure

• Valves are thin folds of tunica interna designed to prevent backflow
Varicose Veins

• Twisted, dilated superficial veins
  – caused by leaky venous valves
    • congenital or mechanically stressed from prolonged standing or pregnancy
  – allow backflow and pooling of blood
    • extra pressure forces fluids into surrounding tissues
    • nearby tissue is inflamed and tender

• Deeper veins not susceptible because of support of surrounding muscles
Blood Distribution

- 60% of blood volume at rest is in systemic veins and venules
  - function as blood reservoir
    - veins of skin & abdominal organs
  - blood is diverted from it in times of need
    - increased muscular activity produces venoconstriction
- hemorrhage causes venoconstriction to help maintain blood pressure
Circulatory Routes

- Systemic circulation is left side heart to body & back to heart
- Hepatic Portal circulation is capillaries of GI tract to capillaries in liver
- Pulmonary circulation is right-side heart to lungs & back to heart
- Fetal circulation is from fetal heart through umbilical cord to placenta & back
Systemic Circulation

- All systemic arteries branch from the aorta
- All systemic veins drain into the superior or inferior vena cava or coronary sinus to return to the right-side of heart
Arterial Branches of Systemic Circulation

- All are branches from aorta supplying arms, head, lower limbs and all viscera with O2 from the lungs
- Aorta arises from left ventricle (thickest chamber)
  - 4 major divisions of aorta
    - ascending aorta
    - arch of aorta
    - thoracic aorta
    - abdominal aorta
Aorta and Its Superior Branches

- Aorta is largest artery of the body
  - ascending aorta
    - 2 coronary arteries supply myocardium
  - arch of aorta -- branches to the arms & head
    - brachiocephalic trunk branches into right common carotid and right subclavian
    - left subclavian & left carotid arise independently
  - thoracic aorta supplies branches to pericardium, esophagus, bronchi, diaphragm, intercostal & chest muscles, mammary gland, skin, vertebrae and spinal cord
Abdominal Aorta and Its Branches

- Supplies abdominal & pelvic viscera & lower extremities
- Splits into common iliac arteries at 4th lumbar vertebrae
Coronary Circulation

- Right & left coronary arteries branch to supply heart muscle
Veins of the Systemic Circulation

- Drain blood from entire body & return it to right side of heart
- Deep veins parallel the arteries in the region
- Superficial veins are found just beneath the skin
- All venous blood drains to either superior or inferior vena cava or coronary sinus
Major Systemic Veins

- All empty into the right atrium of the heart
  - superior vena cava drains the head and upper extremities
  - inferior vena cava drains the abdomen, pelvis & lower limbs
  - coronary sinus is large vein draining the heart muscle back into the heart