Chapter 21 Blood Vessels and Circulation Lecture Outline

Vessels
1. Arteries
2. Arterioles
3. Capillaries
4. Venules
5. Veins
6. Anastomoses

Wall structure
1. Tunica intima
   Endothelium
   Internal elastic membrane
2. Tunica media
   External elastic membrane
3. Tunica externa
   Vasa vasorum

Arteries vs. Veins

Arteries
1. Elastic arteries
2. Muscular arteries
   pressure points
3. Arterioles
   Vasoconstriction
   Vasodilation

Problems:
   Aneurysm
   Arteriosclerosis
   Focal calcification
   Atherosclerosis
   CVA (stroke)

Capillaries
1. Continuous capillaries
2. Fenestrated capillaries
3. Sinusoids

Capillary beds
   Precapillary sphincter
   Vasomotion

Veins
1. Venules
2. Medium veins
3. Large veins

Venous valves

Problems:
   Varicose veins
   Hemorrhoids

Anastomoses

Circulation
Blood flow
Blood pressure
Resistance
Vasoconstriction
Vasodilation

Systemic blood pressure
Systolic
Diastolic
Hypertension

Capillary exchange
Filtration
   blood hydrostatic pressure
Diffusion
Edema

Cardiovascular regulation
1. Autoregulation
   Local vasodilators:
     ↑ CO₂ ↓ O₂
     lactic acid
     ↑ K⁺ or H⁺
     inflammation: histamine, NO
     ↑ temperature
   Local vasoconstrictors
     prostaglandins
     thromboxane
     endothelins

2. Neural
   A. Cardiovascular centers
      1. Cardiac centers
         Acceleratory: sympathetic
         Inhibitory: parasympathetic
      2. Vasomotor centers: sympathetic
         NE
   B. Reflexes
      1. Baroreceptor reflexes
      2. Chemoreceptor reflexes

3. Hormonal
   A. Antidiuretic hormone (ADH)
   B. Angiotensin II
   C. Erythropoietin (EPO)
   D. Atrial Natriuretic Peptide (ANP)

Hemorrhaging
1. Short term
   A. ↑ CO
   B. vasoconstrict
   C. NE, ADH, Angiotensin II

2. Long term
   A. fluid recall
   B. ADH
   C. ↑ thirst
   D. EPO

Shock
Circulatory collapse

Aging
↓ hematocrit
↑ thrombus
↓ valve function
↓ max CO
↑ arteriosclerosis
Relationship of blood and lymphatic vessels

Six Main Classes of Blood Vessels:

1. Arteries - carry blood away from heart, branch and decrease in diameter
2. Arterioles - smallest arterial branches, connect to capillaries
3. Capillaries - tiny vessels where diffusion occurs between the blood and interstitial fluid
4. Venules - smallest veins, connect to capillaries
5. Veins - return blood to heart, converge and increase in diameter
6. Anastomoses - bypass connections between vessels
Three main layers or tunics:

1. Tunica intima / tunica interna = inner most layer
   - endothelial cells with basal lamina of loose connective tissue containing elastic fibers (elastin)
   - (endothelium = simple squamous epithelial-like cells connected by tight junctions)
   - in arteries, the outer edge has extra layer of elastic fibers called the internal elastic membrane

2. Tunica media = middle layer
   - smooth muscle cells in loose connective tissue with sheets of elastin
   - in arteries the outer edge has extra layer of elastic fibers called the external elastic membrane

3. Tunica externa / tunica adventitia = outer most layer
   - collagen rich external connective tissue sheath
   - infiltrated with nerve fibers and lymphatic vessels
   - large vessels contain vasa vasorum
   - in arteries there is more collagen and scattered elastic fiber bands
   - in veins there is extensive elastic fiber networks and bundles of smooth muscle cells
Arteries vs Veins Comparison

**Arteries**
- Thicker walls
- More elastin and smooth muscle in tunica media
- Thickest tunic = tunica media
- Elastic walls recoil constricting lumen without BP
- Circular in cross section
- No valves
- Pleated endothelium
- Internal and external elastic membranes

**Veins**
- Thinner walls
- Less
- Thickest = tunica externa
- Open lumen, no recoil
- Collapse flat in cross section
- Valves = flaps of tunica intima prevent backflow
- Smooth endothelium
- No elastic membranes

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**Histology of blood vessels**

*Images showing different types of blood vessels and their structures.*

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*Source: Amy Warenda Czura, Ph.D.*

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*SCCC BIO132 Chapter 21 Handout*
Types of Vessels

Arteries: designed to change diameter, elastic and muscular, thick walls
   Tunica externa contains collagen
   Sympathetic stimulation = vasoconstriction
   Smooth muscle relaxes = vasodilation

1. Elastic arteries a.k.a. conducting arteries
   Transport large volumes away from heart
   Diameter up to 2.5cm
   Elastin in all three tunics
   Stretch (ventricular systole) and rebound (ventricular diastole)
   Not involved in systemic vasoconstriction

2. Muscular arteries a.k.a. distribution arteries
   Transport blood to organs and tissues
   Diameters 10mm-0.3mm
   More smooth muscle and less elastin in tunica media than elastic arteries
   Involved in systemic vasoconstriction via sympathetic stimulation

3. Arterioles a.k.a. resistance vessels
   Connect blood supply to capillary beds
   Diameters 300µm-10µm
   All three tunics thin with few elastic fibers
   Involved in local vasoconstriction via endocrine or sympathetic stimulation

Capillaries: designed to allow diffusion to/from the tissues
   Consist of tunica intima only (endothelium + basal lamina)
   Diameter 8µm

1. Continuous capillaries
   Normal diffusion to all tissues except epithelium and cartilage
   Complete endothelium, tight junctions

2. Fenestrated capillaries
   High volume fluid or large solute transfer
   Pores/fenestrations span endothelium
   e.g. choroid plexus, endocrine organs, intestine, kidney

3. Sinusoids
   Cell or large protein exchange
   Gaps between endothelial cells
   e.g. liver, bone marrow, lymphoid tissues

Organized into capillary beds between arteriole and venule
Controlled by precapillary sphincters: vasomotion
Veins: designed to return blood to heart, can serve as blood reservoir, thin walls but large lumens
  Thin tunica media with little smooth muscle or elastin
  Tunica externa contains elastin and smooth muscle
  Tunica intima contains valves to prevent back-flow

1. Venule
   Collect blood from capillary beds
   Average diameter 20µm (range 8µm –1.5mm)
   Small ones lack tunica media

2. Medium vein
   Diameters 2-9mm

3. Large vein
   Diameters up to 3cm

Anastomoses: bypass routes between vessels
  Not present in retina, kidney, or spleen
  More common in veins
Cardiovascular Regulation

1. Autoregulation
   single capillary bed: action at a precapillary sphincter
   Local vasodilators: (increase blood flow)
   Increased CO₂ or decreased O₂
   Lactic acid
   Increase K⁺ or H⁺
   Inflammation: histamine, NO
   Elevated temperature
   Local vasoconstrictors: (decrease blood flow)
   Prostaglandins
   Thromboxanes
   Endothelins

2. Neural Mechanisms
   A. Cardiovascular centers in medulla oblongata
      Cardiac centers
      Cardioacceleratory center: sympathetic = increase CO
      Cardioinhibitory center: parasympathetic = decrease CO
      Vasomotor centers = sympathetic
      NE = vasoconstriction
   B. Baroreceptor reflexes
      Monitor BP and trigger cardiovascular centers
   C. Chemoreceptor reflexes
      Monitor blood and CSF CO₂, O₂, and pH and trigger respiratory and cardiac centers

3. Hormonal Regulation
   A. Antidiuretic Hormone (ADH)
      From pituitary gland in response to low blood volume
      Causes vasoconstriction and water conservation at kidney
   B. Angiotensin II
      From kidney in response to low BP
      Causes: Na⁺ retention and K⁺ loss at kidney,
      Stimulates release of ADH, Stimulates thirst, Stimulates CO
      Stimulates arteriole constriction
   C. Erythropoietin
      From kidney in response to low O₂
      Stimulates production and maturation of RBCs
   D. Atrial Natriuretic Peptides (ANP)
      From atria in response to stretching
      Causes: Increased Na⁺ and H₂O loss at kidney,
      Reduced thirst
      Blocks ADH release
      Stimulates vasodilation