Comparative Structure of Artery and Vein Vessel Walls

- Arteries: have greatest pressure

1. Tunica Interna
   a. Endothelium
   b. Basement membrane
   c. Internal elastic lamina

2. Tunica Media
   a. Smooth muscle
   b. External elastic lamina

3. Tunica Externa
   a. Connective tissue
Comparative Structure of Artery and Vein Vessel Walls

- **Veins**: have lowest pressure
  1. **Tunica Interna**
     a. Endothelium
     b. Basement membrane
  2. **Tunica Media**
     a. Smooth Muscle
  3. **Tunica Externa**
     a. Connective Tissue

- **Capillary**
  a. Endothelium
  b. Basement membrane

Classification of Arteries

- **Elastic Arteries**
  (Conducting arteries)
  Aorta, Brachiocephalic, Common Carotid, Subclavian, Vertebral, Pulmonary, Common Iliac

- **Muscular Arteries**
  (Distributing Arteries)
  Brachial artery, Radial artery, Popliteal, Common Hepatic
Circulation Through a capillary bed

- Arterioles: deliver blood to capillaries
- Metarterioles: emerges from arterioles and supplies a group of capillaries
- Thoroughfare Channel: arise from metarterioles and contain no smooth muscle. Thoroughfares allow blood to bypass the capillary

Different types of Capillaries

- Continuous Capillaries
  Plasma membranes of endothelial cells form a continuous tube only interrupted by intercellular clefts (gaps between cells) (lungs and muscle)
- Fenestrated Capillaries
  Plasma membrane of endothelial cells contain pores or fenestrations (Kidney and villi of small intestines)
Different types of Capillaries

- Sinusoids:
  Wider and more winding than other capillaries, with incomplete basement membranes and large fenestrations
  (red bone marrow and liver)

Blood distribution in the Cardiovascular System

- Pulmonary vessels: 12%
- Systemic arteries and arterioles: 15%
- Systemic capillaries: 5%
- Systemic veins and venules (blood reservoirs): 60%
- Heart: 8%
Mechanisms of Capillary Exchange

- Simple Diffusion: (CO₂, O₂, glucose, amino acids, and hormones)
- Transcytosis: Substances enter lumen side of endothelial cells via endocytosis and exit the other side via exocytosis
- Bulk Flow: Substances dissolved in fluid are moved in the same direction as the fluid

Forces involved in Capillary Exchange

- Arterial end of capillary: net filtration
- Venous end of capillary: net reabsorption
- Net filtration pressure (NFP)
- Pressures promoting filtration = (BHP + IFHP)
- Pressures promoting reabsorption = (BCOP + IFHP)
- NFP = (16 + 1) – (26 + 0) = 10 mm Hg
  - Net filtration
- NFP = (26 + 1) – (26 + 0) = 0 mm Hg
  - Net reabsorption
Factors that Affect Capillary Exchange

- Edema = increased Interstitial Fluid
  1. Increased BHP
     a. increased CO
     b. increased blood volume
  2. Increased Permeability of Capillaries
     a. Increased IFOP
     b. Bacteria
     c. Tissue damage
  3. Decreased reabsorption
     a. Decreased BCOP: liver disease, burns, kidney disease
     b. Lymphatic blockage: cancer and parasites
Elephantiasis: is a rare disorder of the lymphatic system caused by parasitic worms such as *Wuchereria bancrofti*, *Brugia malayi*, and *B. timori*, all of which are transmitted by mosquitoes. Inflammation of the lymphatic vessels causes extreme enlargement of the affected area, most commonly a limb or parts of the head and torso. It occurs most commonly in tropical regions and particularly in parts of Africa.
Blood Pressure

The pressure exerted on the walls of a blood vessel. Clinically, BP refers to pressure in arteries.
Systolic pressure = the force of blood recorded during ventricular contraction.
Diastolic pressure = the force of blood recorded during ventricular relaxation

Normal Adult BP: 120/80

Factors that affect blood pressure include:
- a) cardiac output
- b) blood volume
- c) viscosity of blood
- d) resistance
- e) elasticity of arteries

Relationship between Blood Pressure, Cuff Pressure, and Korotkoff Sounds

- Blood Pressure is measured in the Brachial Artery using a Sphygmomanometer
- As cuff pressure drops to a point where it equals systolic pressure, the first Korotkoff sound is heard
- As cuff pressure continues to drop to the point where it equals diastolic pressure, the last Korotkoff sound is heard
- Blood pressure is recorded as the first sound (systolic) and the last sound (diastolic) pressure
Korotkoff Sounds

Factors That Affect Circulation

- **Velocity of Blood:**
  1. Measured as the volume of blood that flows through any tissue in a given time period.
  2. Velocity is inversely related to cross-sectional area
     - Aorta: 3-5 cm², 40 cm/sec
     - Capillaries: 4,500-6,000 cm²/0.1 cm/sec
     - Vena Cavas: 14 cm², 5-20 cm/sec
Factors That Affect Circulation

• Resistance:
  Measured as the opposition to blood flow through blood vessels due to friction between the blood and vessel walls.
  1. Average vessel radius: Resistance is inversely proportional to the fourth power of the radius.
  2. Blood viscosity: Resistance is directly proportional to viscosity.
  3. Total vessel length: Resistance is directly proportional to vessel length.

Factors That Affect Circulation

• Volume of Blood Flow:
  Measured by Cardiac Output
  \[ CO = SV \times HR \]

• Blood Pressure:
  Measured as the hydrostatic pressure exerted on vessel walls by the blood
  Young Adult: 120/80
  120 = ventricular systole
  80 = ventricular diastole
  Mean arterial blood pressure:
  \[ MABP = \text{diastolic BP} + \frac{1}{3}[\text{Pulse Pressure (PP)}] \]
  \[ \text{PP} = (\text{systolic BP} - \text{diastolic BP}) \]
Factors That Affect Circulation

• Cardiac Output is directly related to blood pressure

\[ \text{CO} = \frac{\text{MABP}}{R} \]

\( R = \text{Resistance} \)

Action of Skeletal Muscle in Venous Return

• While standing at rest, venous valves are open

• Contraction of muscles pushes blood upward through the proximal valve, back-pressure closes the distal valve

• As muscle relaxes, pressure drops closing the proximal valve. Higher blood pressure in the foot opens the distal valve allowing blood to flow into section of the vein.
Summary of Factors that Increase Blood Pressure

Overview of Hormones that Regulate Blood Pressure

1. Cardiac Output:
   - Increased CO = Increased BP
   - Increased CO and contractility
     - Epinephrine from Adrenal Medulla
     - Norepinephrine from sympathetic neurons
Overview of Hormones that Regulate Blood Pressure

• Systematic Vascular Resistance
  1. Vasoconstriction (increased)
     a. Angiotensin II
     b. ADH (vasopressin)
     c. Epinephrine
     d. Norepinephrine
  2. Vasodilation (decreased)
     a. ANP
     b. Epinephrine
     c. Nitric Oxide

Overview of Hormones that Regulate Blood Pressure

• Blood Volume
  1. Increased
     a. Aldosterone
     b. ADH
  2. Decreased
     a. ANP
TYPES OF SHOCK

1. Hypovolemic shock = due to decreased blood volume
2. Cardiogenic shock = due to poor heart function.
3. Vascular shock = due to inappropriate vasodilation.
   (example = too long in hot tub)
4. Obstructive shock = due to obstruction of blood flow such as by a pulmonary embolism

Signs and symptoms of shock include:
   a) pulse weak but rapid
   b) skin is cool, pale and clammy
   c) rapid resting heart rate
   d) systolic blood pressure is low (<90 mm Hg)
   e) patient may be thirsty and/or nauseous
   f) confused mental state due to lack of oxygen to the brain

Hypovolemic Shock

Due to decreased blood volume: hemorrhage or excessive fluid loss
(vomiting, diarrhea, burns, dehydration, sweating, increased urine output)

• Stages of shock
  Stage 1: compensated or nonprogressive
  Stage 2: decompensated or progressive (up to 25% loss)
  Stage 3: irreversible shock (death)
Hypovolemic Shock

Stage 1: compensated or non-progressive
   a. Activation of the sympathetic nervous system
   b. Activation of the renin-angiotensin pathway
   c. Release of ADH
   d. Signs of clinical hypoxia

Stage 2: Decompensated or progressive (up to 25% loss)
   a. Depressed cardiac activity (MABP as low as 60)
   b. Depressed vasoconstriction (MABP as low as 40)
   c. Increased capillary permeability
   d. Intravascular clotting
   e. Cellular death occurs
   e. Respiratory acidosis

Negative Feedback Response to Hypovolemic Shock
CNS Input and Regulation of Cardiac Activity

ANS Regulation of Cardiac Activity