20 Cardiovascular System
Blood Vessels

Taft College Human Physiology
The Vascular System: Blood Vessels and Hemodynamics

• **Blood Vessels**
• Blood vessels serve as tubing for the cardiac output: to dynamically distribute the CO to various organs and back to the heart again.
• In other words, the vessels permit the direction of blood flow to be altered.
• When a specific tissue become active, that tissue receives more blood.
Categories of Blood Vessels

1. **Arteries** - carry blood away from the heart.
   - Largest are elastic (aorta & pulmonary).
   - They stretch when the ventricles eject the blood, then recoil, moving blood along.
   - Large arteries branch to form smaller arteries called arterioles.

2. **Arterioles** - contain layers of smooth muscle capable of constriction that alters:
   - a. Peripheral resistance.
   - b. Blood pressure.
   - c. Total blood flow.
   - d. Direction of blood flow.
   - Arterioles are very numerous therefore they will exhibit a greater total cross-sectional area than arteries.
   - Total cross sectional area = sum of the C.S.A. of all blood vessels of a particular type.
Categories of Blood Vessels

3. **Capillaries** - by far the most numerous and extensive of all blood vessels.
   - Exhibit the greatest total cross-sectional area of all vessels. Capillary walls are extremely thin and 'porous' - 1 cell-layer thick.
   - Serve as **area of exchange** of materials between blood and tissues. Form capillary beds or networks that are very extensive.
   - No cell in the body is more than 3 cell distances from a capillary.
   - Total volume of capillaries is so large that not all can be open at the same time as there is not enough blood.
   - There are shunts (valves) that shut off flow to certain parts of capillary beds.

(e) Red blood cells passing through a capillary

Courtesy Michael Ross, University of Florida
Categories of Blood Vessels

- 4. **Venules** - drain the capillary beds, plus some minor exchange of materials through walls.
- 5. **Veins** - return blood to the heart.
- Contain one-way valves. Serve primarily as conducting vessel.
- Blood pressure continues to decline with length of the veins.
5 Factors That Effect Blood Pressure

1. Cardiac output
2. Peripheral resistance
3. Elasticity of large arteries
4. Blood volume
5. Blood viscosity (thickness)
Hemodynamics
Factors Affecting Blood Flow

- Cross sectional area of the blood vessels (sum of the cross sectional area of all blood vessels of one type) has a major effect on blood flow.
- As cross sectional area increases, velocity of the blood decreases.
- Velocity of the blood decreases from aorta to arteries to capillaries and increases in venules and veins.
- As CSA increases blood pressure decreases. Once the blood pressure is lost in the capillaries it can not be regained even though CSA of venules and veins increases.

Where is highest pressure? Lowest?
Where is highest velocity? Lowest?
Where is highest CSA? Lowest?

Cross Sectional Area of Blood Vessels
At rest, most of your blood is located in your **systemic venules and veins**.

**Location of the Blood at Any Given Time at Rest**

- Systemic veins and venules (blood reservoirs) 64%
- Systemic capillaries 7%
- Systemic arteries and arterioles 13%
- Heart 7%
- Pulmonary vessels 9%
How Does Blood Return to the Heart? (at such low pressure?)

Six things serve to return blood back in the direction of the heart.

1. **Skeletal muscle pump** - Blood is circulated by skeletal muscle action, that squeezes the veins and move the blood along.

2. **One-way valves** - The veins contain one-way valves. Once blood is moved past a valve, it cannot move backwards, and thus is kept moving towards the heart.

3. **Thoracic pump** - Inhaling also aids in blood return by creating negative pressure.
   As the thorax expands, so do the large veins within the thoracic region which act like a suction pump to draw venous blood and lymph toward the heart.

4. **Gravity** aids the return of blood for vessels above the heart.

5. **Ventricular relaxation** creates suction (negative pressure) along with the thoracic pump.

6. **Residual Blood pressure** – created by the left ventricle.

   **Note:** This is identical to the list for lymph except for #6 as the lymphatic system has no designated pump.
Blood Pressure Measurements

- **Systolic pressure measurement** - the pressure when the first pulse sound is heard after releasing a cuff around the brachial artery. The force in the artery due to contraction of the left ventricle.
- **Diastolic pressure measurement** - The pressure when the last pulse sound is heard after releasing the cuff. The force in the artery as a result of ventricular relaxation and rest. Provides information about systemic vascular resistance.

- **Hypertension** - high blood pressure
  - above 140
  - 90
- **Hypotension** - low blood pressure
  - below 90-100
  - 50-60
- **Normotensive (Basal State)**
  - 115 (90-120)
  - 70 (60-80)

- All measurements are in mm of Hg (mercury)

Pulse pressure = systolic – diastolic = 40 mm

Mean arterial pulse pressure = \( \frac{systolic + diastolic}{2} = 100 \) mm
Shock

- An inadequate cardiac output that results in a failure of the cardiovascular system to deliver enough O2 and nutrients to meet metabolic needs of body tissues.
- Cellular death may follow if not corrected.
- Causes: Many causes.
- Examples: 3 types
  - **Hypovolemic**
    - Decreased blood volume: acute blood loss, excessive fluid loss (vomiting, diarrhea, dehydration, burns).
    - 10% volume drops tolerated by compensation mechanisms, 15-25% volume loss leads to dramatic drops in CO and BP.
  - **Vascular shock**
    - Blood volume is normal but circulation is inadequate as a result of extreme vasodilation that causes an abnormal expansion of capillaries (vascular bed).
    - Huge drop in peripheral resistance.
    - Example triggers:
      - **Allergic hypersensitivity**— body wide vasodilation due to massive histamine release from mast cells in tissue.
        - Antigen combines with IgE antibody attached to mast cell, which signals histamine release.
      - **Septic shock**— massive infection with bacteria. Some bacterial toxins are effective vasodilators.
  - **Cardiogenic shock**
    - Pump failure occurs when heart is so inefficient that it cannot maintain adequate circulation.
Lecture Exam 3

• 75 Points Possible
• 50 Multiple choice @ 1 Pt each.
• 25 Points Essay – 5 essays@ 5pts each
• Write on one topic in each of the following 5 categories.
  • Cat.1- 2 topics, Cat. 2- 4 topics, Cat.3 – 3 topics,
    Cat. 4 – 3 topics, Cat. 5 – 2 topics. =14 topics total to choose from.
• + 5 Pt. Bonus Category – Essay on Endocrine System – 3 topics to choose from.