

TOPICS 16: CARDIOVASCULAR SYSTEM: BLOOD VESSELS

I. Arteries (Fig 14.7)

- A. Function
 1. Rapid transit pathways from heart to tissues; offer little resistance to flow
 2. Pressure reservoir to provide driving force while heart is relaxing

II. Arterioles: Structure and Function (Figs 14.5 & 14.10)

- A. Branch off of arteries in organs
- B. Arterioles contain smooth muscle which can change the radius of the arteriole
- C. ***Changing radii of arterioles is the major way to regulate blood flow to specific organs, and one of the major ways that arterial blood pressure is controlled.***
 1. Radii of arterioles can be adjusted (independently across arterioles) to
 - a) variably distribute cardiac output among organs
 - b) regulate arterial blood pressure
 - c) bigger radius = vasodilate; smaller radius = vasoconstrict
 2. Convert the pulsing systole-diastole pressure swing into a non-fluctuating pressure

III. Control of Arteriolar Radius

- A. Intrinsic (Local) Factors (Fig 14.12)
 1. Local chemical & physical influences
 - a) Local metabolic changes
 - (1) Increased metabolic demands of a tissue usually result in vasodilation & increased blood flow
 - (2) decreased metabolic demands usually result in vasoconstriction & reduced blood flow.
 - b) Histamine release
 - (1) Synthesized and stored in special connective tissue
 - (2) When tissue damaged or during allergic reactions, histamine released in damaged area, and causes vasodilation, which results in increased blood flow & causes swelling etc.
 - c) Temperature: local heat application causes vasodilation; local cold application causes vasoconstriction
- B. Extrinsic (Neural and Hormonal) Factors
 1. Sympathetic (Epi and Norepi) Control
 - a) Recall that:
 - (1) alpha receptors bind norpei, cause vasoconstriction in arterioles, and are found in arterioles in most organs
 - (2) beta-2 receptors bind epi preferentially and cause vasodilation of arterioles, found in arterioles mostly in cardiac and skeletal muscle
 - b) At rest enough sympathetic activity to maintain tone
 - c) Increased sympathetic activity leads to reduced blood flow to most organs, but increased blood flow to skeletal muscle, heart, and skin (Fig 14.15)
 - d) Regions of brain responsible for adjusting sympathetic output to arterioles: cardiovascular control center in medulla; hypothalamus
 2. Vasopressin and angiotensin II are important in fluid balance & are vasoconstrictors. We'll talk more about these hormones later.

IV. Capillaries

- A. Introduction
1. Site of exchange of materials between blood and tissue
 2. Exchange accomplished primarily by *diffusion*
 3. Need to *minimize diffusion distance* and *maximize surface area and time*
- B. Molecular Structure (Fig 14.19)
1. Composed of a tube of a single layer of flattened endothelial cells (recall that endothelial cells are the *lining* of other blood vessels)
 2. Capillary walls are *very thin to minimize diffusion distance*
 3. Capillary lumen is so narrow that red blood cells must squeeze through single file
 4. Water-filled pores between epithelial cells in wall facilitate exchange
- C. Gross Structure
1. Extensive capillary branching so that all cells in tissues not far from capillaries
 2. **Large overall surface area**
 - a) 10 to 40 billion capillaries in your body
 - b) Total Surface Area: 600 m²!!!
 - c) Volume of blood in capillaries to capillary surface area: *half pint of paint spread over floor of a high school gym.*
 3. **Velocity of blood very slow** in capillaries, *maximizes time* for exchange
 - a) Don't confuse **flow rate (liters/minute)** with **velocity (mm/sec)**!! Flow rate is always equal to cardiac output in all blood vessels; if blood is pumping 5 liters/minute, then every minute 5 liters of blood passes through arteries, arterioles, capillaries and veins.
- D. Function: Exchange material with cells
1. Passive Diffusion
 - a) Most important method of capillary exchange
 - b) Diffusion occurs between capillaries and interstitial fluid, then between interstitial fluid and cells
 - (1) recall: ECF is composed of plasma (20%) and interstitial fluid (80%)
 - c) Lipid soluble substances (e.g., O₂ and CO₂) pass through endothelial cells by dissolving in lipid bilayer of membrane
 - d) Small water soluble substances (ions, glucose, amino acids) pass through water filled pores.
 2. Bulk Flow
 - a) A volume of protein-free plasma filters out of capillaries, mixes with surrounding interstitial fluid, and is subsequently reabsorbed.
 - b) Bulk flow does not play a big role in exchange of materials between plasma and interstitial fluid because quantity of solutes so moved is relatively small compared to those that move by diffusion
 - c) Importance: **distributing ECF between plasma & interstitial fluid.**
- E. Control of flow through capillaries
1. Capillaries have no smooth muscle & hence can not regulate blood flow
 2. Precapillary sphincters contract & relax & control blood flow into capillaries; these sphincters are regulated by the same local factors that influence arteriolar radius.
 3. In resting muscle, only about 10% of precapillary sphincters are open.

V. Lymph System (Fig 14.25)

- A. Problem: Under normal circumstances, slightly more fluid is filtered *out* of capillaries during bulk flow than is reabsorbed back into capillaries. Need to get this fluid back into cardiovascular system.
- B. Solution: Extra fluid is picked up by lymph system, an extensive network of one-way vessels that run from tissues to venous system near right atrium, and so is returned to circulatory system.
- C. Most important functions of lymph system
 1. Return to cardiovascular system excess fluid filtered out of capillaries (about 3 liters/day; note that plasma volume is only about 2.75 liters)
 2. Return to cardiovascular system protein that got out of capillaries
 3. Disease Defense: lymph nodes contain specialized cells to destroy pathogens

VI. Veins

- A. Function
 1. Low resistance passageways to return blood to heart
 2. Serve as capacitance (storage) vessels
 - a) have thin, stretchable but not elastic walls
 - b) can distend to accommodate lots of blood
 - c) *Under resting conditions, 60% of blood is in veins* (Fig 14.22)
 3. A delicate balance exists among capacity of veins, extent of venous return, and cardiac output
- B. Venous Return
 1. General
 - a) At a constant blood volume, as venous capacity increases, venous return decreases, and lowers effective circulating volume.
 - b) Likewise at constant blood volume, as venous capacity decreases, effective circulating volume increases (i.e., less blood is being held in veins).
 2. Factors influencing venous return (volume of blood entering each atrium/minute)
 - a) Driving pressure from cardiac contraction
 - b) Sympathetic activity
 - (1) Sympathetic stimulation causes venous vasoconstriction which elevates venous pressure which causes higher venous return
 - c) Skeletal muscle activity
 - (1) skeletal muscle pump: activity increases venous return. Also counteracts the effects of gravity (Fig 14.23)
 - d) Venous valves
 - (1) One way valves in veins prevent backflow of blood away from heart
 - e) Respiratory activity
 - (1) Pressure within chest cavity is 5 mm Hg less than rest of body because of respiratory activity. This adds to pressure gradient difference between limbs and chest cavity
 - f) Cardiac suction
 - (1) During ventricular contraction, AV valves are drawn downward, enlarging the atrial cavities and causing atrial pressure to drop below 0 mm Hg, which increases pressure gradient. Like a suction pump.