An Introduction to Blood Vessels and Circulation

• the five general classes of blood vessels in the cardiovascular system are: arteries, arterioles, capillaries, venules and veins
  • which vessels carry blood away from the heart?
  • which vessels return blood to the heart?
• read page 616 for an interesting and useful overview of blood vessels

The Structure of Vessel Walls

• list the three distinct layers of the walls of arteries and veins:

  • examine Fig. 19-1 as you study the three layers
    (1) **tunica intima** - innermost layer; it includes:
      ∙ **endothelium**
        - formed by a simple squamous epithelium
        - lines the lumen (the hollow center through which blood flows)
      ∙ underlying CT
      ∙ **internal elastic membrane** (only in arteries, not veins)
    (2) **tunica media**
      ∙ it contains what type of muscle tissue?
        - the smooth muscle is arranged *circularly* around the lumen deep to the tunica intima
        - what happens to the diameter of the vessel when these smooth muscle cells contract?
        - what happens to the diameter of the vessel when these smooth muscle cells relax?
    (3) **tunica externa**
      ∙ the outermost, connective tissue layer

Differences between Arteries and Veins

• which have a thicker wall, arteries or veins?
• which typically contain valves, arteries or veins?

Arteries

• their relatively thick, muscular walls make arteries what?
• elasticity allows arteries to absorb what?

  • what division of the autonomic nervous system innervates the smooth muscle?
• when stimulated, arterial smooth muscles contract, thereby constricting the artery—a process called what?
• relaxation of the smooth muscles increases the diameter of the lumen—a process called what?

**Arterioles**
• arterioles are the smallest of the arteries
• the diameters of arterioles change in response to what?

**Capillaries**
• capillaries are tiny tubes formed by a simple squamous epithelium
• capillaries are the only blood vessels whose walls permit what?

- this is because they have thin walls and blood flow through them is relatively slow
• what is the average diameter of a capillary?
• the number of capillaries varies with the type and metabolic activity of body tissue
  • tissues with high metabolic activity, such as muscles, the liver, the kidneys, and the nervous system, need more oxygen and nutrients and therefore have extensive capillary networks
  • tissues with lower metabolic requirements, such as tendons and ligaments, have fewer capillary networks; epithelial tissue, cartilage, and the cornea and lens have no capillaries
• there are three types of capillaries: (Fig. 19-2 and 19-4 show two of the three types)
  1. **CONTINUOUS CAPILLARIES**
     • the endothelium is complete and forms a continuous tube
     • found in skeletal muscle tissue and smooth muscle tissue, CTs, and the lungs
  2. **FENESTRATED CAPILLARIES**
     • the cell membranes of the epithelial cells have numerous small pores called fenestrations; the pores permit what?

• fenestrated capillaries are found in the kidneys, villi of the small intestine, choroid plexuses of the brain, and some endocrine glands
  3. **SINUSOIDS**
     • are flattened, irregularly shaped, and have gaps between adjacent endothelial cells; the basal lamina is thinner or absent
     • sinusoids permit a free exchange of what?

• sinusoids occur in what organs?

**Capillary Beds** (see Fig. 19-5)
• do capillaries function as individual units?
• what is the interconnected network of capillaries called?
· what does a **precapillary sphincter**, formed by smooth muscle cells, guard?

- contraction of the smooth muscle cell(s) of this sphincter narrows the diameter of the capillary entrance, thereby doing what?

**Vasomotion**
· read the paragraphs pertaining to vasomotion on pages 623 and 624
· define **vasomotion**:

· when you are at rest, blood flows through what percent of your capillaries at any given time?

**Veins**
· veins collect blood from all tissues and organs and return it to what?

**The Distribution of Blood**
· examine Fig. 19-7 and note the distribution of blood in the cardiovascular system at rest; which vessels contain the highest percent of total blood volume at a given time, arteries, capillaries or veins?

**Blood Pressure (BP)**

*Hydrostatic Blood Pressure (BP)* = the force that blood exerts on the vessel wall

(This is usually what we refer to as plain old “blood pressure”, but the use of the term “hydrostatic” is more specific and distinguishes it from osmotic BP)

**systolic arterial BP** = the pressure in arteries when the ventricles are contracting

**diastolic arterial BP** = the pressure remaining in the arteries when the ventricles are relaxing

Blood flows through a system of blood vessels due to pressure differences created by contraction of the heart (from region of high to low hydrostatic BP). Other mechanisms that aid in blood flow are:

1. **valves** – prevent backflow of blood
2. **contracting skeletal muscles** – help squeeze blood through nearby vessels
3. **pressure changes** created during respiration

**Factors that affect hydrostatic blood pressure**

1. **cardiac output**
   · blood pressure varies directly with cardiac output
2. **blood volume**
   · blood pressure varies directly with blood volume
3. **peripheral resistance**
   · peripheral resistance is the opposition to blood flow; it is a measure of the amount of friction blood encounters as it passes through vessels
   · blood pressure varies directly with peripheral resistance
three important sources of peripheral resistance:

a. **blood viscosity**
   - related to the thickness of blood; normally is fairly constant

b. **total blood vessel length**
   - peripheral resistance (and therefore BP) varies directly with total blood vessel length

c. **blood vessel diameter**
   - peripheral resistance (and therefore BP) varies indirectly with blood vessel diameter
   - ↓ blood vessel diameter → ↑ peripheral resistance → ↑ BP
   - ↑ blood vessel diameter → ↓ peripheral resistance → ↓ BP

*Blood viscosity and total blood vessel length typically remain fairly constant.*
*Blood vessel diameter is variable and is the main means by which the body regulates blood pressure (through peripheral resistance).*
*Arterioles can dilate or constrict in response to neural and chemical controls, and are the major determinants of peripheral resistance and, therefore, BP.*

**The vasomotor center controls the diameter of blood vessels:**

**VASOMOTOR CENTER**
- is a cluster of sympathetic neurons in the medulla oblongata that controls diameter of blood vessels
- continuous moderate impulses from the vasomotor center maintains arterioles in a constant state of moderate constriction, called *vasomotor tone*

- *the activity of the vasomotor center is modified by input from:*
  
  a. **baroreceptors**
     - special sensory cells in some large arteries such as the aortic arch that detect changes in arterial blood pressure

  b. **chemoreceptors**
     - special sensory cells in the aortic arch and other large arteries that detect changes in blood levels of oxygen, carbon dioxide, and hydrogen ions (pH)

  c. **higher brain centers**
     - input from the cerebral cortex and hypothalamus can influence the vasomotor center

- *substances that influence blood pressure by acting directly on the smooth muscle of blood vessels or directly on the vasomotor center:*
  
  a. **epinephrine and norepinephrine**
     - hormones released by the adrenal medulla
     - in general, promote vasoconstriction
     
     *(nicotine in tobacco causes vasoconstriction directly and stimulates the release of the above hormones)*

  b. **ADH**
     - hormone produced by the hypothalamus and released from the posterior lobe of the pituitary
     - stimulates the kidneys to conserve water
     - also, in large amounts, causes intense vasoconstriction
c. **angiotensin II**
   - release of rennin from the kidneys leads to the formation angiotensin II in the blood, which stimulates intense vasoconstriction

d. **histamine and other chemicals released during inflammation**
   - potent vasodilators

e. **alcohol**
   - inhibits release of ADH, depresses the vasomotor center, promotes vasodilation of the skin

*Now, more about [**BLOOD PRESSURE**]*)
- examine Fig. 19-10 to answer these questions:
  - blood pressure is highest in what type of vessel: aorta, arterioles, capillaries, venules or vena cava?
  - blood pressure is lowest in what type of vessel: aorta, arterioles, capillaries, venules or vena cava?

**Capillary Pressures and Capillary Exchange**
- review the definition of capillary exchange (p. 626)
- list the three most important processes that move materials across typical capillary walls (return to p 734):

1. **Diffusion**
   - define diffusion:
   - define concentration gradient:
   - read about the 5 different routes by which different substances diffuse across capillary walls

2. **Filtration**
   - what is the driving force for filtration?
   - what occurs in capillary filtration?
   - filtration occurs primarily at what end of a capillary and why?

3. **Reabsorption**
   - occurs as the result of what?
   - define osmosis *(I know you know this already!)*:
   - osmotic pressure is an indication of what?
   - the higher the solute concentration, is the solution’s osmotic pressure higher or lower?
- what creates blood colloid osmotic pressure?

**The Interplay between Filtration and Reabsorption**

* to understand this and to answer some of the questions, see Fig. 19-12 as you work through this:

summary of the two main pressures involved during capillary exchange:

1. **capillary hydrostatic pressure**: is due to the pressure blood exerts on the blood vessel wall. This pressure tends to push fluid out of the capillary into the interstitial fluid (filtration)

2. **blood colloid osmotic pressure**: is due to the presence of plasma proteins in the blood; they are too big to pass out thru capillaries and they exert an osmotic pressure that tends to pull interstitial fluid into the capillary (reabsorption)

**net filtration pressure** is the difference between the above 2 pressures

AT THE ARTERIOLE END OF A BLOOD CAPILLARY:

- which is higher, capillary hydrostatic pressure or blood colloid osmotic pressure?
- therefore there is a net movement of water and solutes into or out of the blood capillary?
- what is this movement called?

AT THE VENOUS END OF A BLOOD CAPILLARY:

- which is higher, capillary hydrostatic pressure or blood colloid osmotic pressure?
- therefore there is a net movement of water and solutes into or out of the blood capillary?
- what is this movement called?

* Does all of the fluid that is filtered out of the capillary get reabsorbed?!

- of the roughly 24 liters of fluid that moves out of the plasma and into the interstitial fluid each day, 20.4 liters is reabsorbed
  - so, what percent of the fluid filtered out of capillaries is reabsorbed?
  - the remaining 15% drains into lymphatic capillaries and is carried by lymphatic vessels eventually to the venous system

- read the “Clinical Note” on p.633 and define edema:
  - what is the underlying problem in all types of edema?
  
  -some examples of causes of edema:
  1. increased capillary hydrostatic pressure → causes excess filtration
  2. increased permeability of capillaries → causes excess filtration
  3. decreased concentration of plasma proteins (hypoproteinemia) → causes inadequate reabsorption
  4. what if someone has the larvae of a parasitic worm blocking their lymphatic capillaries (as in the disease called “elephantiasis”)?

The End!