Chapter 15  Adapted form Tortora 10th ed.

LECTURE OUTLINE

A. Anatomy of Blood Vessels (p. 454)
   1. Blood vessels are tubes that carry blood away from the heart toward the tissues of the body and then return the blood to the heart.
   2. Arteries carry blood away from the heart.
   3. Arteries branch extensively and eventually give rise to arterioles.
   4. Arterioles branch into capillaries; substances are exchanged between the blood and surrounding tissues through the walls of capillaries.
   5. Capillaries merge to form venules.
   6. Venules merge to form veins.
   7. Veins merge with each other to form progressively larger veins which carry the blood back to the heart.
   8. Larger blood vessels are served by their own blood vessels called vasa vasorum, located within their walls.

B. Arteries (p. 454)
   1. Blood flows through the lumen of arteries (and other blood vessels).
   2. The walls of arteries consist of three layers:
      i. inner tunica interna (intima) which consists of:
         a. endothelium
         b. basement membrane
         c. internal elastic lamina
      ii. middle (thickest) tunica media which consists of:
         a. elastic fibers which provide compliance (i.e., distensibility)
         b. smooth muscle fibers
      iii. outer tunica externa which consists of:
         a. primarily elastic and collagen fibers
         b. external elastic lamina may be present
   3. Vasoconstriction occurs when vascular smooth muscle tissue contracts to decrease the diameter of the lumen.
   4. Vasodilation occurs when vascular smooth muscle tissue relaxes to increase the diameter of the lumen.
   5. There are two major sets of arteries:
      i. large elastic (conducting) arteries whose elastic fibers recoil during relaxation of the heart to force blood to flow onward; these blood vessels act as pressure reservoirs
      ii. medium-sized muscular (distributing) arteries whose smooth muscle tissue is capable of greater vasoconstriction and vasodilation to regulate the rate of blood flow to target tissues

C. Arterioles (p. 454)
   1. An arteriole is a very small branch of an artery that delivers blood to a capillary.
   2. Through vasoconstriction and vasodilation arterioles play major roles in:
      i. regulating blood flow from arteries to capillaries
      ii. regulating blood pressure
3. Arterioles are therefore known as **resistance vessels**.

D. **Capillaries** (p. 456)

1. A capillary is a microscopic blood vessel that usually connects an arteriole to a venule; the flow of blood from arterioles to venules through capillaries is called the **microcirculation**.
2. Many body tissues have extensive **capillary networks** (e.g., muscles, liver, kidneys) but some have fewer capillaries (e.g., tendons and ligaments) or no capillaries (e.g., all covering and lining epithelia, cornea, lens, and cartilage).
3. Capillaries are called **exchange vessels** because the primary function of capillaries is to permit the **exchange** of nutrients and wastes between the blood and surrounding tissue cells; this occurs easily because the walls of capillaries consist of only two thin layers:
   i. endothelium
   ii. basement membrane
4. A **metarteriole** emerges from an arteriole and supplies a group of 10-100 capillaries that form a **capillary bed**; the proximal portion of a metarteriole has scattered smooth muscle fibers that regulate blood flow through the capillary bed, but the distal portion of a metarteriole, which empties into a venule, has no smooth muscle fibers and is called a **thoroughfare channel**.
5. **True capillaries** emerge from arterioles or metarterioles and are not on the direct flow route from arteriole to venule; at their sites of origin, there is a ring of smooth muscle fibers called a **precapillary sphincter** that controls, via **vasomotion**, the flow of blood into a true capillary.
6. Many capillaries are **continuous capillaries** in which the plasma membranes of the endothelial cells form a continuous tube that is interrupted only by **intercellular clefts**.
7. Other capillaries are **fenestrated capillaries** in which there are **fenestrations** (pores) between the neighboring plasma membranes.
8. In some organs, there are **sinusoids** which are wider, more tortuous capillaries whose walls contain large pores and intercellular clefts; sinusoids may contain specialized lining cells (e.g., phagocytic cells in liver sinusoids).
9. A **portal system** delivers blood from one capillary network directly to another capillary network.

E. **Venules** (p. 457)

1. Several capillaries unite to form small veins called venules.
2. Venules deliver blood from capillaries to veins.

F. **Veins** (p. 458)

1. Veins have relatively thin walls because the tunica interna and tunica media are thin layers.
2. Many veins have **valves** which:
   i. are composed of two or more thin folds of tunica interna that form flap-like **cusps** which project into the lumen.
   ii. function to **prevent backflow of blood** and aid in moving blood toward the heart
3. A **vascular (venous) sinus** is a vein with a thin endothelial wall that has no smooth muscle to alter its diameter (e.g., coronary sinus).

G. **Anastomoses** (p. 459)
1. The union of branches of two or more arteries supplying the same body region is called an anastomosis; anastomoses provide alternative routes, i.e., collateral circulation, for blood to reach a target tissue or organ (anastomoses may also occur between veins and between arterioles and venules).

2. Arteries that do not anastomose are called end arteries; occlusion of an end artery interrupts the blood supply to the target tissue and may result in necrosis of that tissue.

H. Blood Distribution (p. 459)

1. Systemic veins and venules contain, at rest, about 60% of the blood volume and are therefore called blood reservoirs.

2. When more blood is needed elsewhere, vasoconstriction reduces the volume of blood in venous reservoirs in order to provide a greater volume to active tissues (e.g., active skeletal muscles).

3. Vasoconstriction of veins, called vеноconstriction, also helps to compensate for blood pressure decrease during hemorrhage.

4. The major blood reservoirs are the veins of the abdominal organs (especially the liver and spleen) and the skin.

I. Circulatory Routes (p. 459)

1. Blood vessels are organized into parallel circulatory routes that deliver blood throughout the body.

2. The circulatory routes are:
   i. **systemic circulation**, which includes all blood vessels carrying blood from the left ventricle, through body organs, and back to the right atrium; its subdivisions include:
      a. **coronary (cardiac) circulation**
      b. **cerebral circulation**
      c. **hepatic portal circulation**
   ii. **pulmonary circulation**, which includes all blood vessels carrying blood from the right ventricle, through the lungs, and back to the left atrium
   iii. **fetal circulation** exists only in the fetus and consists of structures that permit exchange of substances between the developing fetus and its mother.

3. **Systemic Circulation**: (p. 459)
   i. The systemic circulation delivers oxygen and nutrients to tissues and removes carbon dioxide and other wastes and heat from the tissues of the body.
   ii. All systemic arteries branch from the aorta which consists of the following segments:
      a. **ascending aorta**
      b. **arch of the aorta**
      c. **thoracic aorta**
      d. **abdominal aorta**
   iii. All systemic veins deliver blood to (all of which empty into the right atrium):
      a. **superior vena cava**
      b. **inferior vena cava**
      c. **coronary sinus**
   iv. The principal arteries and veins of the systemic circulation are described in the following sequence:
      Exhibit 15.1 The Aorta and Its Branches
4. **Hepatic Portal Circulation**: (p. 500)
   i. A portal system carries blood between two capillary networks without passing through the heart.
   ii. The **hepatic portal circulation** carries blood from capillaries of the gastrointestinal organs and spleen to sinusoids of the liver; the liver stores, modifies, or detoxifies some of the substances that have been absorbed by the gastrointestinal tract.
   iii. The hepatic portal system includes the veins that drain blood from the pancreas, spleen, stomach, intestines, and gallbladder and transport it to the hepatic portal vein.
   iv. The **hepatic portal vein** is formed by the union of two veins:
      a. **superior mesenteric vein** which drains blood from the small intestine, portions of the large intestine, stomach and pancreas
      b. **splenic vein** which drains the spleen and receives tributaries from the stomach, pancreas, and portions of the large intestine
   v. The liver also receives oxygenated blood via the **hepatic artery**.
   vi. All blood leaves the liver via **hepatic veins** which drain into the inferior vena cava.

5. **Pulmonary Circulation**: (p. 501)
   i. The pulmonary circulation delivers deoxygenated blood from the right ventricle to the air sacs of the lungs and returns oxygenated blood from the lungs to the left atrium.
   ii. The **pulmonary trunk** emerges from the right ventricle and divides into the **right** and **left pulmonary arteries** which enter and branch extensively within the lungs.
   iii. After gas exchange within the **pulmonary capillaries**, oxygenated blood flows into blood vessels that unite to eventually form two **pulmonary veins** that exit each lung and travel to the left atrium.
   iv. The pulmonary and systemic circulations are different in several ways:
      a. blood in the pulmonary circulation need not be pumped as far as blood in the systemic circulation
      b. pulmonary arteries have larger diameters, thinner walls, and less elastic tissue; consequently, resistance to blood flow is very low and therefore less pressure is needed to move blood through the lungs
      c. as a result, normal pulmonary capillary hydrostatic pressure is lower than average systemic capillary hydrostatic pressure

6. **Fetal Circulation**: (p. 501)
   i. The fetal circulation permits the fetus to obtain oxygen and nutrients from the maternal blood and eliminate its carbon dioxide and wastes into the maternal blood.
ii. The exchange of substances between the fetal blood and maternal blood occurs through the **placenta**, which attaches to the navel (umbilicus) of the fetus by the **umbilical cord**.

iii. Deoxygenated blood flows from the fetus to the placenta via two **umbilical arteries**.

iv. Oxygenated blood returns from the placenta to the fetus via one **umbilical vein** which delivers its blood primarily to the **ductus venosus** that drains into the inferior vena cava.

v. Since fetal lungs do not operate, most fetal blood does not flow from the right ventricle to the lungs; structural features that permit most blood to bypass the lungs include:
   a. **foramen ovale** between the right and left atria
   b. **ductus arteriosus** that permits most blood in the pulmonary trunk to flow into the aorta

vi. At birth, when pulmonary, renal, and digestive functions begin, the special structures of the fetal circulation are no longer needed and consequently undergo specific vascular changes, including the following:
   a. the distal portions of the umbilical arteries become the ** medial umbilical ligaments**
   b. the umbilical vein collapses but remains as the **ligamentum teres** (round ligament)
   c. the ductus venosus collapses but remains as the **ligamentum venosum**
   d. the placenta is expelled as the “**afterbirth**”
   e. the foramen ovale normally closes to become the **fossa ovalis**
   f. the ductus arteriosus closes and becomes the **ligamentum arteriosum**

J. **Development of Blood Vessels and Blood** (p. 505)
   1. Blood and blood vessel formation start initially in the **mesoderm** of the yolk sac, chorion, and body stalk.
   2. Blood vessels and blood cells develop from precursor cells called **hemangioblasts**.
   3. Blood vessels develop from **angioblasts** (derived from hemangioblasts); angioblasts aggregate to form **blood islands** which grow and fuse to form blood vessels.
   4. Blood cells develop from **pluripotent stem cells** (derived from hemangioblasts).

K. **Aging and the Cardiovascular System** (p. 505)
   1. The effects of aging on the cardiovascular system include:
      a. decreased compliance (extensibility) of the aorta
      b. reduction in cardiac muscle fiber size
      c. progressive loss of cardiac muscle strength
      d. reduced cardiac output
      e. decline in maximum heart rate
      f. increase in blood pressure
      g. increase in total blood cholesterol and LDL levels along with decrease in HDL level
      h. increase in incidence of coronary artery disease (CAD), congestive heart failure, and atherosclerosis
L. **Key Medical Terms Associated with Blood Vessels** (p. 507)
   1. Students should familiarize themselves with the glossary of key medical terms.