

Cardiovascular System: The Heart

Chapter 20

SIZE, FORM, AND LOCATION OF THE HEART

FIGURE 20.2a

1. The heart is a cone-shaped structure that is approximately the size of a fist.
2. The **apex** (tip) of the heart points inferiorly, and the **base** of the heart is superior. Thus the cone is upside down.
3. The heart is part of the **mediastinum**, a partition of organs that divides the thoracic cavity into right and left halves.

ANATOMY OF THE HEART

Pericardium

FIGURE 20.3

1. The heart is enclosed by a double-layered sac called the **pericardium**, or the **pericardial sac**. The pericardium has two main parts.
 - A. The outer **fibrous pericardium** consists of connective tissue and is responsible for the strength of the pericardium.
 - B. The inner **serous pericardium** is simple squamous epithelium that secretes serous fluid. It protects the heart against friction. The serous pericardium has two parts.
 - 1) The **visceral pericardium** is in contact with the heart.
 - 2) The **parietal pericardium** is in contact with the fibrous pericardium.
 - 3) The **pericardial cavity** in-between the visceral and parietal pericardium is filled with **pericardial fluid**.
2. **Pericarditis** is inflammation of the pericardium that can cause substernal pain. It can be caused by infections or damage caused by radiation treatment for cancer.
3. **Cardiac tamponade** [tam-pō-nAd'] is compression of the heart due to an accumulation of fluid in the pericardial space. Decreased venous input results in decreased output and death can result. Cardiac tamponade can be caused by pericarditis (build up of pericardial fluid) or wounds, such as stab or gunshot wounds (buildup of blood).

Heart Wall

The wall of the heart has three layers.

FIGURE 20.4

1. The **epicardium** is the outermost layer. The epicardium is also called the visceral pericardium (two different names for the same structure). The epicardium is simple squamous epithelium plus connective tissue and fat.
2. The **myocardium** is the middle layer. It is composed of cardiac muscle. Contraction of the cardiac muscle provides the force that propels blood through the heart.
3. The **endocardium** is the inner layer. It consists of simple squamous epithelium (endothelium). The smooth surface of the endocardium reduces friction as blood flows through the heart.

EXTERNAL ANATOMY

FIGURE 20.5

1. Blood vessels leave and enter the heart through the base of the heart. For example, the aorta carries blood away and the superior vena cava carries blood to the heart.
2. The heart has four chambers.
 - A. The two **atria** (sing., atrium) form the superior part of the heart. The **auricles** are flaplike extensions of the atria.
 - B. The two **ventricles** form the larger, inferior part of the heart
3. Externally the chambers are marked by grooves in the surface of the heart.
 - A. The **coronary sulcus** separates the atria from the ventricles.
 - B. The **interventricular sulcus** separates the right and left ventricles.
 - C. The sulci contain blood vessels that supply the myocardium with blood.
3. The coronary circuit.

FIGURE 20.6

- A. The **coronary circuit** provides the blood supply to the heart.
- B. At the base of the aorta the **left** and **right coronary arteries** branch off of the aorta and are located in the coronary sulcus.

- C. The arteries subdivide eventually giving rise to capillaries. Exchange of gases, nutrients, and waste products takes place in the capillaries.
- D. The capillaries combine to form **cardiac veins**. About 75% of coronary return is through the **coronary sinus**. Some of the cardiac veins empty directly into the right atrium.
- E. Blockage of the coronary arteries.
 - 1) A **myocardial infarct**, or **heart attack**, is blockage of a coronary artery resulting in an inadequate blood flow to some part of the heart and eventually death of cardiac tissue.
 - a. Small amounts of tissue destruction may not be noticed.
 - b. Large amounts of tissue destruction are recognized as a heart attack and can result in death.
 - 2) **Angina pectoris** is a temporary reduction in blood delivery. It often results from atherosclerosis, which reduces blood flow, combined with increased demand on heart function.
 - 3) Reduced blood supply often produces pain in the area of the epigastrium, sternum, left shoulder, and inner part of the left arm. This is referred pain to the skin of these areas.
- G. **Aortic coronary bypass surgery**.
 - 1) If the coronary artery is blocked in a few locations, it may be possible to graft a vessel to the coronary artery past the blockage site. In this way, blood can reach heart muscle.
 - 2) One type of coronary bypass involves grafting a vessel (usually the great saphenous vein taken from the thigh) between the aorta and the coronary artery past the point of blockage.
 - 3) Another procedure frees one end of a vessel (internal thoracic artery) from the interior of the chest wall and attaches the end to the coronary artery. Studies now show that this chest vessel is less likely to later become blocked than the thigh vessel. [After five years, 80% of internal thoracic OK compared to 67% of great saphenous]
 - 4) Usually 1 to 3 grafts are done. Immediate results are good (as measured by improvement in quality of life). In severe heart disease, surgery improves survival time. However, in less severe disease, long term survival may not be better than that obtained with drug therapy.

Heart Chambers and Valves

The heart has four chambers, two atria and two ventricles.

FIGURE 20.7 and 20.8

1. The atria are separated from each other by the **interatrial septum**.

2. The ventricles are separated from each other by the **interventricular septum** (not visible in the illustration).
3. The atria and ventricles are connected to each other by the **atrioventricular canals**.

Atrioventricular Valves

FIGURE 20.8 and 20.9

1. The **atrioventricular valves** are located between the atria and the ventricles in the atrioventricular canals.
 - A. The **tricuspid valve** is located between the right atrium and the right ventricle. It has three cusps or flaps.
 - B. The **bicuspid valve (mitral valve)** is located between the left atrium and the left ventricle. It has two cusps.
2. The atrioventricular valves function to keep blood from flowing back into the atria when the ventricles contract.
 - A. The **chordae tendineae** attach the valves to the **papillary muscles** of the heart wall.
 - B. Contraction of the papillary muscles produces tension on the chordae tendineae that prevents them from inverting.

Semilunar Valves

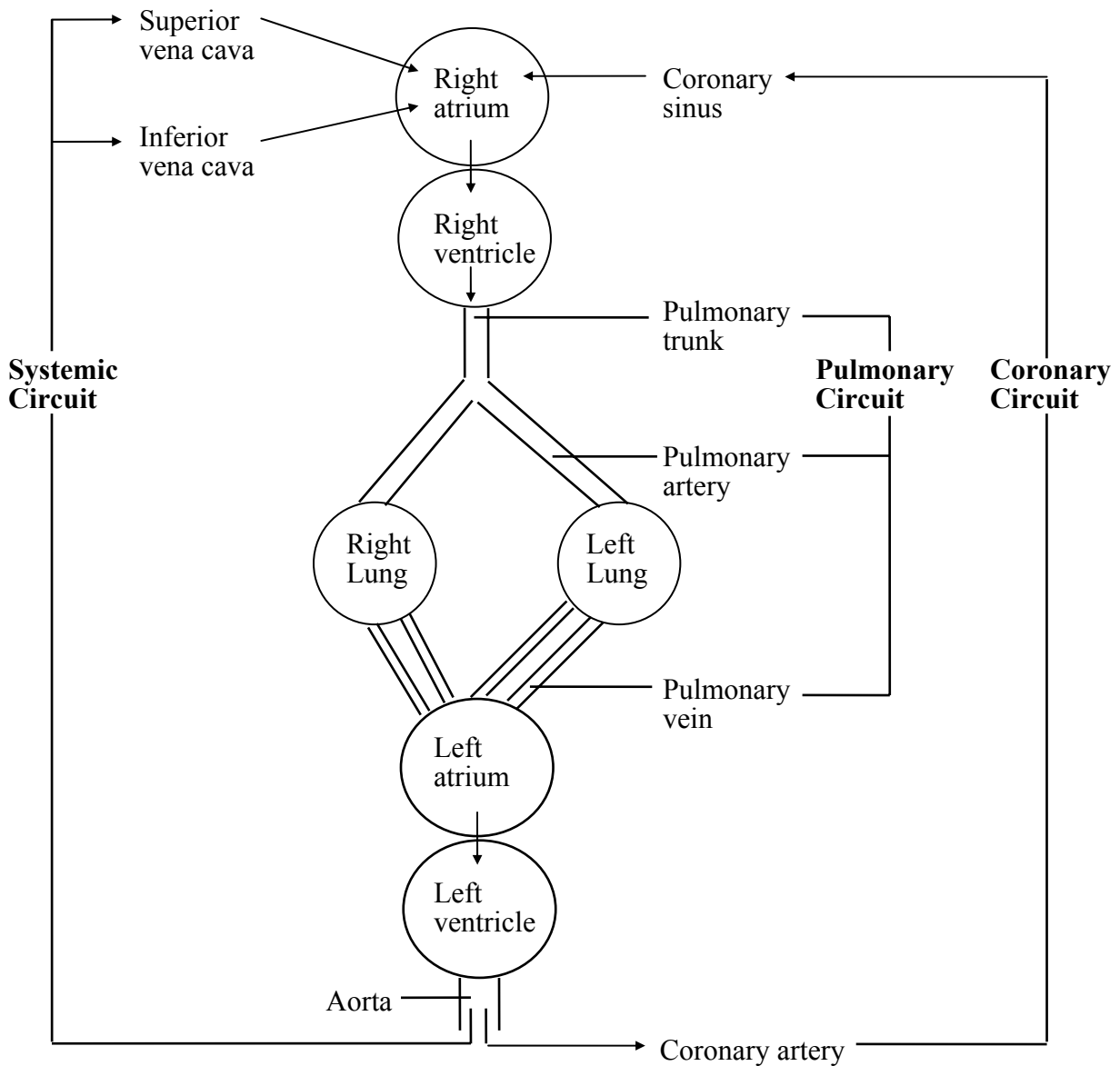
FIGURE 20.8 and 20.9

1. The semilunar valves are located between the ventricles and the blood vessels draining the ventricles.
 - A. The **pulmonary semilunar valve** is between the right ventricle and the pulmonary trunk.
 - B. The **aortic semilunar valve** is between the left ventricle and the aorta.
2. The semilunar valves function to keep blood from flowing back into the ventricles after they have finished contracting. Each semilunar valve has three cusps. Blood fills each cusp, causing the cusps to come together and occlude the valve opening.

ROUTE OF BLOOD FLOW THROUGH THE HEART

FIGURE 20.1 and 20.10

1. The heart functions as a double pump (i.e., a left and right pump). Each pump has a receiving chamber, the atrium, and a propulsion chamber, the ventricle.
2. Pump function.
 - A. The right pump consists of the right atrium, which receives blood that has passed through the vessels of the body, and the right ventricle, which sends blood to the lungs through the **pulmonary circuit**.
 - B. The left pump consists of the left atrium, which receives newly oxygenated blood from the lungs, and the left ventricle, which sends the blood to the body through the **systemic circuit**, and to the heart through the **coronary circuit**.



3. Vessels associated with the heart.
 - A. The **superior vena cava** returns blood from the head, upper limbs, and thorax to the right atrium.
 - B. The **inferior vena cava** returns blood from the abdomen, pelvis, and lower limbs to the right atrium.
 - C. The **coronary sinus** and **cardiac veins** return blood to the right atrium.
 - D. The **pulmonary trunk** drains the right ventricle. It divides to form the **pulmonary arteries**, each of which goes to one of the lungs.
 - E. The four **pulmonary veins** (two from each lung) return blood from the lungs to the left atrium.
 - F. The **aorta** drains the left ventricle and returns blood to the body and to the coronary circuit of the heart.

Fetal Blood Circulation (see p. 1107-1108) [see Gray/38 p. 1500, 323, 361]

FIGURE 29.21

1. Oxygen-rich blood is carried from the placenta to the liver by the **umbilical vein**. Note: by definition, veins carry blood toward the heart, and arteries carry blood away from the heart. Most veins have oxygen-poor blood, and most arteries have oxygen rich blood. Thus, the umbilical vein is an exception to the general pattern. [Start out with two umbilical veins, but the right degenerates.]
2. The umbilical vein joins the [left branch of the] hepatic portal vein opposite the origin of the **ductus venosus**. Approximately 50% of the blood bypasses the liver by flowing through the ductus venosus, which connects to the inferior vena cava [or the left hepatic vein]. The other 50% flows into the hepatic portal vein to the liver and from the liver to the inferior vena cava [Berne & Levy, Cardiovascular Physiology, 7th ed., p. 262].
3. Blood enters the right atrium.
4. Blood mostly bypasses the fetal lungs which are nonfunctional.
 - A. Blood passes from the right atrium to the left atrium through an opening called the **foramen ovale**.
 - B. Blood passes from the pulmonary trunk to the aorta through a blood vessel called the **ductus arteriosus**.
 - C. Approximately 28% of the blood returning to the heart flows through the foramen ovale, 61% flows through the ductus arteriosus, and 11% goes to the lungs [Milnor, p. 358].
5. Blood flows through the aorta, common iliac arteries, and internal iliac arteries to the **umbilical arteries**. The umbilical arteries conduct oxygen-poor blood to the placenta where the blood is reoxygenated. Note that the umbilical arteries are an exception to the generalization that arteries have oxygen-rich blood.

6. After birth, the connection to the placenta is lost.
 - A. Blood flow from the placenta stops.
 - 1) The umbilical vein closes and becomes the **ligamentum teres (round ligament) of the liver**.
 - 2) The ductus venosum becomes the **ligamentum venosum**.
 - 3) Blood flows through the hepatic portal system of the liver.
 - B. Blood flow to the placenta stops. The umbilical arteries distal to the urinary bladder become the **CORDS OF THE UMBILICAL ARTERIES**. [Also called the medial umbilical ligaments. The remaining part of the umbilical arteries become the vesicular arteries, which supply the urinary bladder.]
7. After birth, all of the blood circulates through the lungs.
 - A. A flap of tissue closes the foramen ovale, which becomes the **fossa ovalis**.
 - B. Action potentials cause the ductus arteriosus to constrict. It becomes the **ligamentum arteriosum**.

HISTOLOGY

Heart Skeleton

FIGURE 20.11

1. The **skeleton of the heart** is supportive fibrous tissue.
 - A. The **fibrous rings** surround the valves and maintain the shape of the valve openings.
 - B. The fibrous tissue provides a place of attachment for the cardiac muscle.
2. The skeleton of the heart acts as an electrical insulator between the atria and ventricles of the heart.