Exercise 22

Cardiovascular Physiology

Laboratory Objectives

On completion of the activities in this exercise, you will be able to:

- Locate the auscultation areas for the heart.
- Use a stethoscope to listen to the heart sounds at the auscultation areas.
- Measure blood pressure at rest, during exercise, and during the recovery period after exercise.
- Calculate the pulse pressure and mean arterial pressure (MAP).
- Measure the pulse rate at rest, during exercise, and during the recovery period after exercise.
- Describe the function of the cardiac conducting system.
- Measure and evaluate the electrical activity of the heart (ECG).

Materials

- Stethoscopes
- Alcohol swabs
- Sphygmomanometers
- Stopwatch or clock with a second hand
- Stationary cycle
- Biopac Student Lab system

The **cardiac cycle** refers to the series of events that occurs during one heartbeat. During one cycle, the two atria will contract at the same time. As the atria relax, the two ventricles will contract simultaneously. A period of contraction in a heart chamber is called **systole** (**atrial systole**, **ventricular systole**), and a period of relaxation is called **diastole** (**atrial diastole**, **ventricular diastole**). In clinical use, these terms typically refer to events in the ventricles, because they are the larger and more powerful chambers that pump blood into the great arteries.

The events of the cardiac cycle are illustrated and described in Figure 22.1. During the cycle, changes in blood pressure inside the chambers and great arteries cause the heart valves to open and close. These events regulate the flow of blood through the heart and into the systemic and pulmonary circuits. During this laboratory exercise you will investigate some of the physiological events—heart valve function, pulse, blood pressure—that characterize the cardiac cycle. You will also record measurements of the electrical activity of the heart (an electrocardiogram or ECG) and evaluate the results.

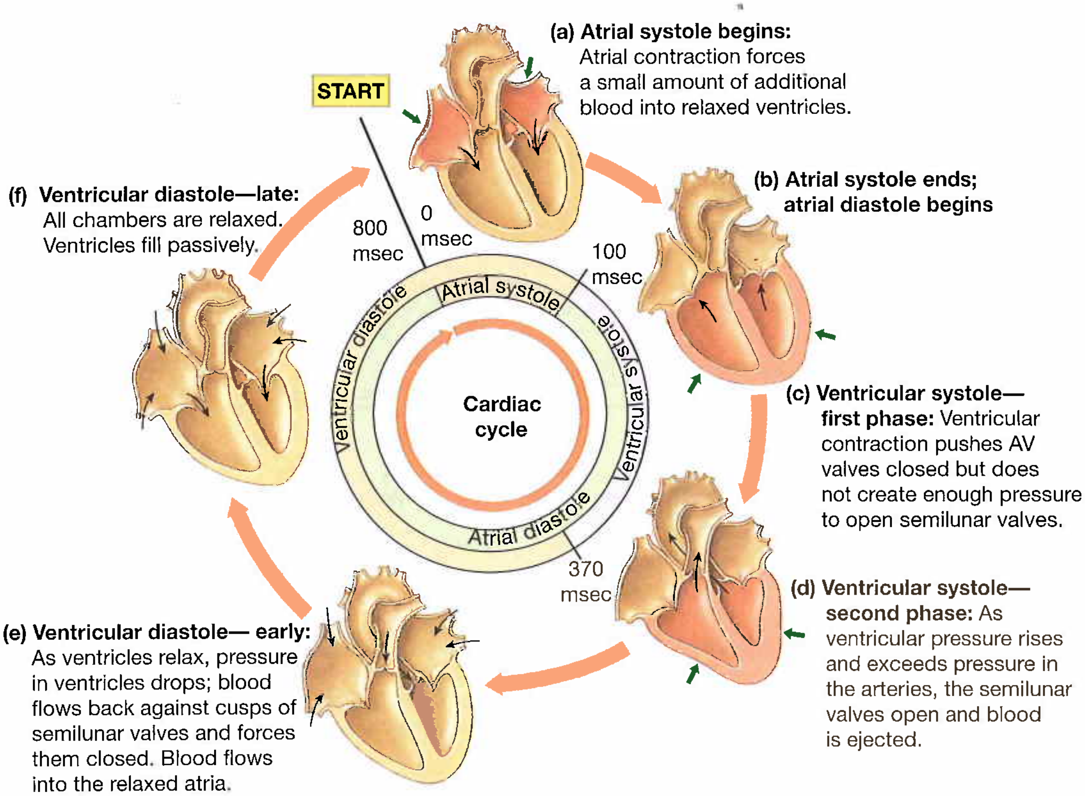

Figure 22.1 The cardiac cycle. The illustrated steps describe the events that occur during one heartbeat. During each cycle, the atria contract together and the ventricles contract together.

Heart Sounds

During the cardiac cycle, when blood passes from the atria to the ventricles and from the ventricles to the great vessels, the heart valves open and close. The closing of the values produces two distinctive heart sounds. The sounds can be heard, with the aid of a stethoscope, as **"lub-dup"** vibrations. The cardiac cycle begins when a small volume of blood is pumped into each ventricle during atrial systole (Figure 22.1a). The first "lub" sound is caused by vibrations that follow the closing of the atrioventricular (AV) valves (Figure 22.2b). This occurs at the end of atrial systole (Figure 22.1b). This point in the cardiac cycle also marks the beginning of ventricular systole (Figure 22.1c), known as **isovolumetric contraction**, when all heart valves are closed. As the pressure in the ventricles increases, the semilunar valves open and blood is pumped into the great vessels. This is the second phase of ventricular systole (Figure 22.1d), known as **ventricular ejection.** The closing of the semilunar valves occurs at the beginning of ventricular diastole (Figure 22.1e). Vibrations, generated by the closing of these valves, creates the second "dup" sound (Figure 22.2b). At this time, pressure in the ventricles is decreasing and falls below the pressure in the great arteries. At the end of the cycle, ventricular pressure falls below the atrial pressure. As a result, the AV valves open and passive filling of the ventricles begins. A new cycle begins with the initiation of atrial systole.

CLINICAL CORRELATION

Incomplete closure of the AV valves can cause regurgitation or backflow of blood into the atria. This can cause an abnormal gurgling sound known as a **heart murmur.** On the left side of the heart, incomplete closure of the biscupid (mitral) valve is called a **mitral valve prolapse.** Minor prolapses are fairly common and most people live with them and do not experience adverse effects. However, a major prolapse, possibly caused by rupturing of the chordae tendinae or severe damage to the cusps, can have serious if not life-threatening consequences.

ACTIVITY 22.1 Listening for Heart Sounds

1. The best locations to hear heart sounds are the **auscultation areas for the heart** (Figure 22.2a) on the anterior thoracic wall. These areas are named after the heart valve that can best be heard. Locate the following auscultation areas on yourself or your lab partner.
   - The **biscupid area** is located in the left fifth intercostal space, where the apex of the heart is located. To find this region, locate the inferior end of the sternum by finger palpation. From this point, move your finger approximately 7 cm (2.75 in) to the left, where you

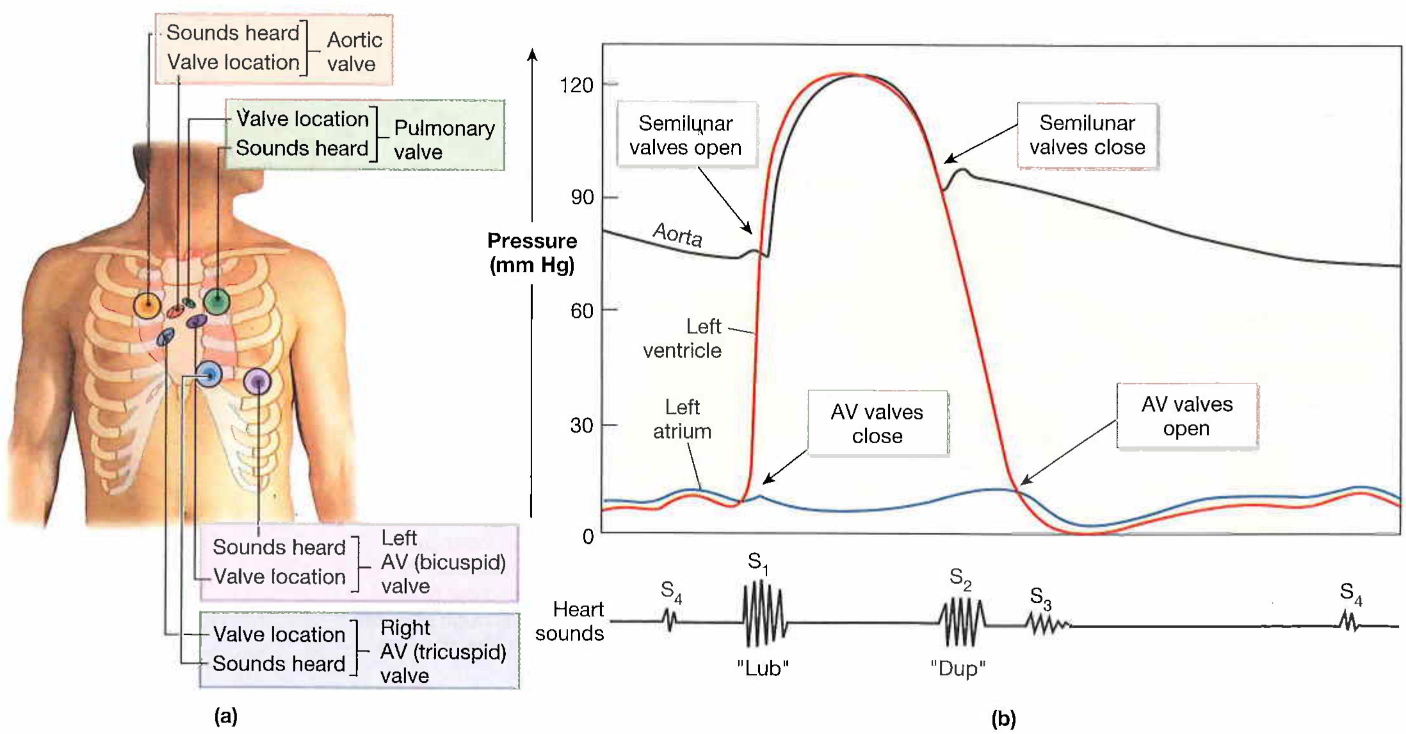

Figure 22.2 Auscultation areas for the heart. a) Diagram that illustrates the locations of the heart valves (oval areas) and the auscultation areas (circular areas), where heart sounds can best be detected with a stethoscope. **b)** Graph showing the relationship of the heart sounds with events in the cardiac cycle. The two primary heart sounds, S_1 and S_2 ("lub-dup"), are caused by the closing of heart valves. Two minor sounds, S_3 and S_4, are not related to valve function and are difficult to hear.

can feel the fifth intercostal space between the fifth and sixth ribs.

- To locate the **tricuspid area**, palpate the inferior end of the sternum and place your stethoscope just to the left of that point.
- The **aortic semilunar area** is located in the second intercostal space, just to the right of the sternum. The second intercostal space can be located by first palpating the superior margin of the manubrium. From this margin, move your finger inferiorly until you can feel the junction between the manubrium and the body of the sternum. If you move your finger laterally to the right of the sternum, you can feel the costal cartilage of the second rib. The second intercostal space is just inferior to this rib. Place your stethoscope in this space, just lateral to the sternum.
- The **pulmonary semilunar area** is located in the second intercostal space, just to the left of the sternum. Follow the same procedure for locating the aortic semilunar area, but this time, move to the left side of the sternum.

WHAT'S IN A WORD The term *auscultation* is derived from the Latin word *ausculto,* which means "to listen." Auscultation is an important diagnostic tool used by doctors and other health care providers. It involves listening to the sounds made by various organs in the thoracic or abdominal cavities, such as the closing of heart valves.

2. Obtain a stethoscope and sterilize the earpieces with an alcohol swab.
3. Place the stethoscope on the bicuspid area and listen for the heart sounds. If the background noise is too high and you are experiencing difficulty in detecting the sounds, move to a quieter area in the laboratory or to another room. Can you hear both heart sounds ("lub-dub") when the stethoscope is placed over the biscuspid area? Can you hear one sound better than the other?

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4. Listen to the heart sounds at the other auscultation areas. How do the sounds compare at each area? Answer the same two questions that were asked for the biscuspid area in the previous step.

	Can you hear both heart sounds?	Can you hear one sound better than the other?
• Tricuspid area	___	___
• Aortic semilunar area	___	___
• Pulmonary semilunar area	___	___

QUESTION TO CONSIDER During a physical examination, why does the doctor listen to the heart sounds at all four auscultation areas?

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Blood Pressure

Blood pressure is the force exerted by blood on the walls of blood vessels. It is a function of the pumping action of the heart and the resistance to flow as blood moves through the blood vessels. Blood flows throughout the circulatory pathways due to the existence of a pressure gradient that allows blood to move from areas of high pressure to areas of low pressure. Blood flow in arteries and veins begins with ventricular ejection into the great arteries and ends with venous return to the atria. In the systemic circulation, blood pressure is highest in the aorta due to the force of ejection by the left ventricle. Pressure gradually declines throughout the circulatory pathway, and is close to zero when blood enters the right atrium.

In large elastic arteries, the blood pressure fluctuates between a maximum and minimum value, which correspond to the cardiac cycle. For example, during ventricular systole, blood is ejected into the aorta from the left ventricle. The force of ejection causes the elastic walls of the aorta to stretch, and the pressure inside the aorta reaches a peak. This maximum pressure is called the **systolic pressure.** During ventricular diastole, the aortic semilunar valve closes, and the elastic fibers in the wall of the aorta recoil to force blood forward. At this time, the aortic pressure declines to a minimum level, referred to as the **diastolic pressure.** Thus, blood pressure in the aorta is not smooth or constant, but pulsatile in nature. This characteristic is also true for other elastic arteries, but it diminishes in the smaller arteries and arterioles as the number of elastic fibers in the vessel walls diminishes. Blood, flowing through capillaries and veins, travels under relatively low pressure with little or no fluctuation.

Blood pressure is measured in units called millimeters of mercury (mm Hg). If the pressure in a blood vessel is 95 mm Hg, it means that the force exerted by the blood will cause a column of mercury to rise 95 millimeters. When blood pressure is measured, it is the **arterial blood pressure** in the systemic circulation that is recorded. Usually, the **brachial artery** is used to measure arterial blood pressure (Figure 22.3), because it is at the same level as the heart, so the effects of gravity are negligible. Thus, blood pressure measurements taken from the brachial artery are fairly close to the blood pressure in the aorta.

Since the pressure in arteries is pulsatile, both systolic and diastolic pressures are measured. If a person's blood pressure is 120/80, it means that the systolic pressure is 120 mm Hg and the diastolic pressure is 80 mm Hg. The systolic pressure represents the force exerted by the left ventricle when it pumps blood into the aorta. The diastolic pressure measures the resistance to blood flow in the arteries.