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Biopac Student Lab® Lesson 17

HEART SOUNDS

Introduction

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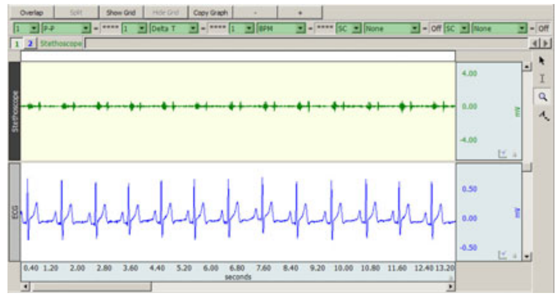

I. INTRODUCTION

In this lesson you will record sounds of the cardiac cycle, producing a record called a phonocardiogram, while simultaneously recording Lead II electrocardiogram. You will compare and correlate electrical events of the cardiac cycle to mechanical events of the cardiac cycle.

The human cardiovascular system consists ofs the heart and blood vessels arranged to form a double circulation: the systemic circulation and the pulmonary circulation. The circulatory pattern resembles a figure 8 with the heart located at the center (Fig. 17.1).

The primary function of the heart is to receive blood from the pulmonary veins and pump it into the systemic arteries, and to receive blood from the systemic veins and pump it into the pulmonary arteries. The sequence of electrical and mechanical events of the heart associated with receiving blood from the venous systems and pumping it out into the arterial systems during one heartbeat is known as the **cardiac cycle**.

A simplistic mechanical analogy of the heart is that of a double-pump. The left and right sides are separate, but pump in unison to move blood through the heart.

The normal flow of blood through the heart and blood vessels is unidirectional, and is as follows:

> **left ventricle** - systemic arterial vessels - systemic capillaries - systemic venous vessels - **right atrium - right ventricle** - pulmonary arterial vessels - pulmonary capillaries - pulmonary venous vessels - **left atrium - left ventricle**.

Blood flowing through the left side of the heart is kept separate from blood flowing through the right side of the heart by the septa (walls) between the atria and between the ventricles.

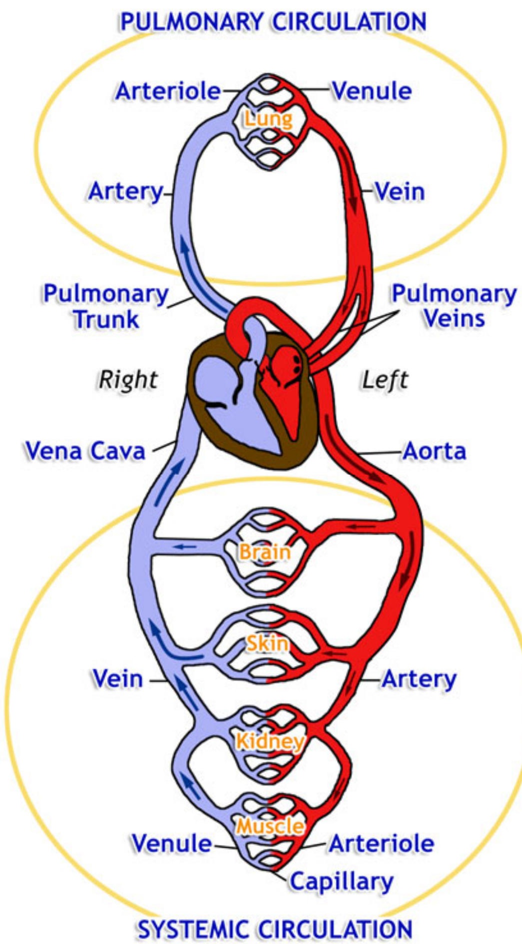

Fig. 17.1 Circulatory Pattern

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The unidirectional flow of blood through the chambers on each side of the heart is ensured by an **atrioventricular valve** and a **semilunar valve** (Fig. 17.2).
On the left side of the heart the atrioventricular valve is called the *mitral valve*, and the semilunar valve is called the *aortic valve*.
On the right side of the heart the atrioventricular valve is called the *tricuspid valve*, and the semilunar valve is called the *pulmonary valve*.
The atrioventricular valve opens into the ventricle, allowing blood to flow from the atrium into the ventricle but not in the reverse direction (retrograde flow). The valve is open when ventricular pressure is less than atrial pressure, thereby allowing the ventricle to fill with blood. The valve is closed when ventricular pressure is greater than atrial pressure, thereby preventing the backward flow of blood.

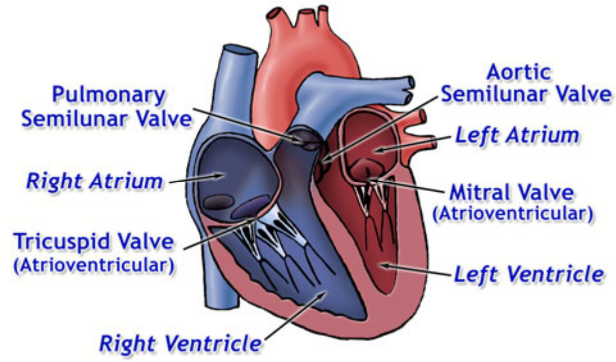

Fig. 17.2 Heart valves

The semilunar valve opens into the artery (pulmonary trunk or aorta) allowing blood to flow out from the ventricle when ventricular pressure is greater than pressure in the artery. The valve is closed when ventricular pressure is less than arterial pressure, thereby preventing the backward flow of blood. During the cardiac cycle, the semilunar valves (pulmonary and aortic) open and close in unison, as do the atrioventricular valves (tricuspid and mitral). This is the “double-pump” action of the heart.

Four major heart sounds are associated with the opening and closing of the valves and the flow of blood within the heart during the cardiac cycle. These sounds may be heard by placing a stethoscope in the corresponding position on the anterior surface of the chest over the heart.

1. The **first heart sound** occurs during ventricular systole (contraction of ventricular muscle) and is caused by closure of the atrioventricular valves and opening of the semilunar valves. This sound is the “lub” of the characteristic “lub-dub” that can be heard with each heartbeat.
2. The **second heart sound** occurs during ventricular diastole (relaxation of ventricular muscle) and is caused by closure of the semilunar valves and opening of the atrioventricular valves. This sound is the “dub.”
3. The **third heart sound** is caused by turbulence associated with rapid filling of the ventricles shortly after opening of the atrioventricular valves.
4. The **fourth heart sound** is caused by turbulence associated with the passage of blood from the atria into the ventricles during atrial systole. This sound is heard immediately before the ventricles begin to contract and force the atrioventricular valve to close.

Note: The first and second heart sounds are sharp and distinct, easily heard by the untrained ear. The third sound closely follows the second and is of lower amplitude (muffled,) which makes it hard to distinguish. The fourth sound is often of such low amplitude that it cannot be detected. For these reasons, discussion of heart sound measurement often refers to only the first and second heart sounds.

Hearing deficits may affect detection and interpretation of the heart sounds. The BIOPAC stethoscope contains a microphone that picks up sounds traveling through the tubing. The microphone is very sensitive and can pick up sounds that may not be heard.
Placement of stethoscope diaphragm to hear corresponding valve sounds is shown in Fig. 17.3.

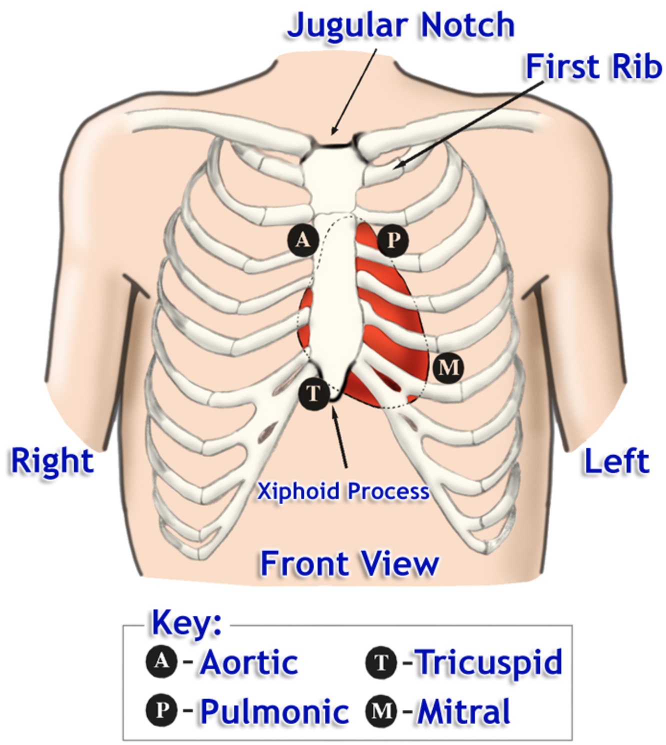

Fig. 17.3 Stethoscope Positions for Optimal Detection of Heart Valve Function

A *heart murmur* is an atypical sound usually produced by abnormal closure of a cardiac valve, narrowing (stenosis) of the valvular orifice, or defects in the atrial septum or ventricular septum. The fundamental cause of the change in sound is increased turbulence. Murmurs may be heard during ventricular systole (systolic murmurs) or during ventricular diastole (diastolic murmurs).

- For example, if the mitral valve fails to completely close, thereby allowing retrograde flow, a systolic murmur may occur. On the other hand, if the aortic valve is diseased and incompetent causing a murmur, the sound will be heard during ventricular diastole.

The opening and closing of cardiac valves and the sounds they produce are mechanical events of the cardiac cycle. They are preceded by the electrical events of the cardiac cycle.

Each heartbeat begins with a signal generated by the sinoauricular (SA) node, commonly called the pacemaker. As the signal spreads through atrial muscle the atria respond by contracting (atrial systole). At this time the ventricles are relaxing (ventricular diastole) and the atrioventricular valves are open, the semilunars are closed. The ventricles are filling with blood, preparing for ejection.

The atrioventricular (AV) node picks up the pacemaker signal and, after a short delay that allows the atria to complete systole and enter diastole, sends the signal down the atrioventricular conduction system to the ventricles stimulating them to contract (ventricular systole). When the ventricles contract, ventricular pressure increases above atrial pressure and the atrioventricular valves close (1st heart sound).

Ventricular pressure continues to increase, and when it exceeds arterial pressure, the semilunars open and blood is rapidly ejected into the pulmonary trunk and aorta. The ventricles complete systole and enter diastole. As the ventricles relax ventricular pressure falls below arterial pressure and the semilunar valves close (2nd heart sound).

When ventricular pressure falls below atrial pressure, the atrioventrcular valves open and ventricular filling begins again. At this time (a period called diastasis) the atria and the ventricles are relaxed and awaiting the pacemaker to signal the next cardiac cycle.

The electrical events of the cardiac cycle can be recorded in the form of an electrocardiogram (ECG).

- At this point, students should review Lesson 5, ECG I, for the meaning of the waveforms, time intervals and segments of Lead II.

Fig. 17.4 shows the timing relationship of the heart sounds and the ECG electrical signal. It also includes aortic, ventricular and atrial pressure plots for the left side of the heart. Pressure waves for the right side (not shown) would have similar shape but be of less amplitude. This is because the pressure that builds up in the chambers of the left side of the heart is much greater than that on the right. The higher pressure on the left causes the valves to snap shut harder and faster, so the valves on the left side create the majority of the sound heard through the stethoscope.

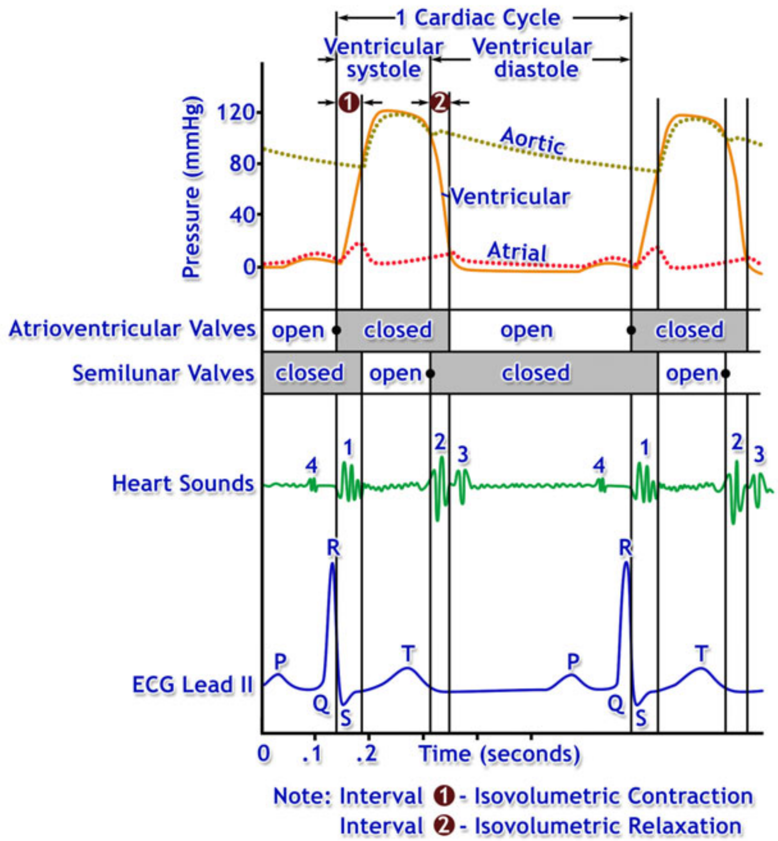

Fig. 17.4 Timing of Events in the Cardiac Cycle