

Overview of Human Anatomy and Physiology: Cardiac Cycle

Introduction

Welcome to the Overview of Human Anatomy and Physiology course on the Cardiac System. This module, the Cardiac Cycle, describes the actions that occur during a heartbeat.

After completing this module, you should be able to:

1. Identify the events of the cardiac cycle.
2. Describe the relationship between cardiac structures and their role in the cardiac cycle.
3. Relate heart sounds to the events of the cardiac cycle.

Overview

Cardiac Cycle

The cardiac muscles of the heart contract and relax in a rhythmic cycle. During the contraction phase, called systole, blood is propelled out of the ventricles and into either the pulmonary or systemic circulations. During the relaxation phase, called diastole, blood fills the emptied ventricles. One complete heartbeat--a systole followed by a diastole--is considered a cardiac cycle. What occurs during systole?

Systole

Atrial Systole

Before atrial systole begins, the ventricles are already 70 percent filled because of passive blood flow from the atria. As the atria contract, the increased pressure causes the atrioventricular (AV) valves to open completely and the ventricles to fill.

Ventricular Systole

As atrial systole ends, ventricular systole begins. When the ventricles begin to contract, ventricular pressures become greater than atrial pressures, forcing closure of the AV valves. The chordae tendineae anchor the AV valves, ensuring one-way blood flow by preventing the valves from opening into the atria.

For a brief period at the beginning of ventricular systole, the aortic pressure is greater than the ventricular pressure, and the ventricle cannot empty. This early phase of systole is called isovolumetric ventricular contraction, because the ventricular volume remains constant despite the ventricle's contraction.

However, as pressure in the ventricles increases and exceeds the arterial pressures, the semilunar valves are pushed open.

Systole of the left ventricle ejects blood into the aorta for entry into the systemic circulation. Systole of the right ventricle forces blood into the pulmonary trunk for entry into the pulmonary circulation. The ventricles do not empty completely, and the amount of blood remaining after ejection is called the end-systolic volume.

What occurs during diastole?

Diastole

Ventricular and Atrial Diastole

When contraction stops, the ventricular muscle relaxes rapidly. The ventricular pressure almost immediately falls below aortic pressure, closing the aortic valve.

However, ventricular pressure remains greater than atrial pressure, and the AV valve remains closed. This period of early diastole is called isovolumetric ventricular relaxation.

As ventricular pressure falls below atrial pressure, the AV valve opens and ventricular filling occurs, rapidly at first and then slowing. As discussed earlier, ventricles fill to approximately 70 percent of capacity during diastole.

Now that we have examined the events of the cardiac cycle, let's investigate their timing.

Cardiac Cycle Timing

Overview

The average adult person at rest has 65 to 75 heartbeats (cardiac cycles) per minute. One complete cardiac cycle takes about 0.8 seconds.

- Atrial systole, where the atria contract and eject blood into ventricles, lasts about 0.1 seconds.
- Ventricular systole, where ventricles contract and eject blood into large arteries, lasts 0.3 seconds.
- Atrial and ventricular diastole, where blood from large veins flows into atria and ventricles, lasts about 0.4 seconds.
- The atria are continuously relaxed and filling with blood from the veins for all but their 0.1-second period of contraction.

Heart Sounds

First and Second Heart Sounds

First and Second Heart Sounds

Two heart sounds are normally heard through a stethoscope placed on the chest wall. These sounds result from vibrations caused by the closure of the heart valves. The first sound is associated with the closure of the AV valves at the beginning of systole and is described as a soft, low-pitched "lub" sound. The second sound is associated with closure of the pulmonary and aortic valves at the beginning of diastole and is described as a louder "dub."

Clinical Correlation: Heart Murmurs

Heart murmurs are sounds that usually result from blood flowing past the valves of the heart. Most of these murmurs are not pathological--that is, they are not due to disease and are found in people with healthy hearts. However, some types of murmurs are caused by the flow of blood past diseased heart valves. Heart-valve disease may result from a defect present at birth, or it may be due to other illnesses, such as heart disease, rheumatic fever, heart attacks, or infection.

The two primary types of heart valve disease are stenosis and insufficiency. Valve stenosis is a condition in which the valves are stiff or fused, causing a constriction in the size of the valve opening. This narrowing limits the amount of blood that can flow past the valve. Valve insufficiency (also called regurgitation) occurs when the cusps of the valves fail to close tightly or fall backwards instead of shutting, allowing blood to leak through them. In mitral and aortic valve stenosis or insufficiency, the heart has to work harder to pump a

sufficient amount of blood to the rest of the body. If these conditions are severe enough, heart failure can result. When valve damage is very severe, surgery is required to replace the diseased valve.

Third and Fourth Heart Sounds

Faint third and fourth heart sounds may be detected as well, but they are not often heard in healthy adults. They usually are not related to valve sounds but are attributed to atrial contraction and ventricular blood flow.

Key Points

- The cardiac cycle is one complete heartbeat, which is a systole followed by a diastole.
- During systole, blood is propelled out of the contracting ventricles and into either the pulmonary or systemic circulations.
- During diastole, blood fills the emptied, relaxed ventricles.
- Heart sounds result from the movement of the heart valves.
- The first heart sound is due to the closure of the AV valves at the beginning of systole.
- The second heart sound is created by the closure of the pulmonary and aortic valves at the beginning of diastole.