Overview of Human Anatomy and Physiology: Structure and Function Overview

Introduction

Welcome to the Overview of Human Anatomy and Physiology course on the Cardiac System. This module, Structure and Function Overview, discusses the anatomy of the heart and its role in the cardiovascular system.

After completing this module, you should be able to:
1. Describe the location of the heart.
2. Describe the function of the pericardium.
3. Identify the major vessels and chambers of the heart and describe the flow of blood through the heart.
4. Identify the major valves of the heart and describe their functions.
5. Describe the heart wall and explain the purpose of coronary circulation.

The Heart

Function
Blood flows through the body to carry oxygen from the lungs to the rest of the body, to clear wastes, and to deliver nutrients, hormones, and enzymes. This crucial circulation begins and ends at the heart, the chief organ of the cardiovascular system.

Pulmonary Circuit
There are two pathways that originate at the heart: the pulmonary circuit and the systemic circuit. The pulmonary circuit transports blood to the lungs, where carbon dioxide is exchanged for oxygen. The right side of the heart pumps deoxygenated blood into the pulmonary circuit. What is the function of the systemic circuit?

Systemic Circuit
The systemic circuit supplies oxygenated blood to the rest of the body and exchanges the oxygen and nutrients for carbon dioxide and wastes. The left side of the heart pumps oxygenated blood into the systemic circuit.

Location
To facilitate pumping thousands of liters of blood each day, the heart has a central location within the thorax, a protective cage created by the ribs and the thoracic vertebrae. The sternum is a long, dagger-shaped bone in the anterior wall of the thorax, and the heart is located just posterior to this bone and near the center of the cavity created by the thorax.

The Pericardium

Structure
The heart is held in place and further protected by a structure within the thoracic cavity called the pericardium. This layered membrane surrounds the fluid-filled pericardial cavity. The outer layer of the pericardium is the parietal pericardium, and the inner layer is the visceral pericardium, or
epicardium. The entire pericardium is surrounded by the pericardial sac, which is formed of tough connective tissue that protects the heart and anchors it in the thoracic cavity.

**Function**

Because the heart moves as it beats, the pericardium must be capable of expanding and contracting as it holds the heart in place. As the heart changes volume, the pericardium also changes volume. The fluid inside the pericardial cavity reduces friction as the epicardium and the rest of the heart move. What are the heart structures that function in pumping blood?

**Chambers and Major Vessels**

**Chambers**

The heart has four chambers for receiving and pumping out blood--the right and left atria and the right and left ventricles. The left atrium and ventricle are part of the systemic circuit, and the right atrium and ventricle are part of the pulmonary circuit.

**Major Vessels**

Blood is carried to and from these heart chambers through vessels. The two types of blood vessels are arteries and veins. Arteries transport blood away from the heart and veins bring blood to it. The vessels that lead directly into or out of the heart chambers are called the major, or “great,” vessels of the heart. Let's take a closer look at the heart's major vessels.

**Venae Cavae**

Blood flows into the right atrium from the systemic circuit through two major veins, the superior vena cava and the inferior vena cava. The superior vena cava carries blood from upper areas of the body--the arms, chest, neck, and head. The inferior vena cava transports blood from the lower trunk and legs. The coronary sinus also enters the right atrium, bringing blood from the veins of the heart itself.

**Pulmonary Trunk and Veins**

From the right atrium, blood passes into the right ventricle and then into the pulmonary trunk, which as the name suggests, is the beginning of the pulmonary circuit. The pulmonary trunk bifurcates into the right and left pulmonary arteries.

Blood returns to the heart from the pulmonary circuit through the right and left pulmonary veins, which are the major vessels that lead into the left atrium. Where does blood flow from the left atrium?

**Ascending Aorta**

Blood then flows from the left atrium into the left ventricle, which pumps it into the ascending aorta. The ascending aorta sends blood into the systemic circuit and into the arteries of the heart itself.

**Clinical Correlation: Cardiopulmonary Bypass**

During most cardiac surgeries, the heart needs to be stopped for a short period of time to allow surgeons proper conditions in which to perform procedures. When the heart is stopped during surgery, a Heart-Lung Machine (HLM) takes over the job of the heart and lungs in a process called cardiopulmonary bypass.
During surgery, a tube, or cannula, is placed into either the right atrium or the superior or inferior vena cavae, and under the force of gravity, blood is drained into the HLM. In the HLM, the blood first passes into an oxygenator, which functions as the lungs by adding oxygen and removing carbon dioxide. The blood then flows through a heat exchanger, which controls blood temperature, and is followed by a filter that removes any blood clots. Finally, blood is returned to the systemic circulation through a cannula placed in the aorta. A pump in the HLM replaces the pumping action of the heart and provides enough force to drive systemic circulation.

Heart Structure

Atrial Physiology

The left and right atria have the same function: They receive blood returning from the pulmonary and systemic circuits, respectively, and then pass the blood on to the ventricles. This similarity in function corresponds with a similarity in structure—the left and right atria appear almost identical.

Ventricular Physiology

The left and right ventricles, however, have quite different roles. The right ventricle pumps blood into the pulmonary circuit, and the left ventricle pumps blood into the systemic circuit. The pulmonary circuit passes through the lungs, which share the thoracic cavity with the heart. The systemic circuit traverses the rest of the body, and the blood must travel much farther.

Because the left ventricle must work harder—six or seven times as much force is required to pump blood through the systemic circuit as is needed for the pulmonary circuit—it has a thicker myocardium than the right ventricle.

What heart structures ensure unidirectional flow of blood through the systemic and pulmonary circuits?

Major Valves

Overview

As blood flows from the atria to the ventricles and from the ventricles into the major arteries, valves ensure that the blood flows in one direction. The valves between the right atrium and ventricle and between the left atrium and ventricle are called the atrioventricular (AV) valves. The valves between the ventricles and the major arteries are called the semilunar valves because of the half-moon shape of the valve flaps. The characteristic heart sounds that can be heard with a stethoscope correspond to the closing of the AV and semilunar valves.

Atrioventricular Valves

The AV valve between the right atrium and ventricle is composed of three flaps, or cusps, and is therefore called the tricuspid valve. The AV valve between the chambers on the left side of the heart has only two cusps, so it is called the bicuspid valve. This valve is also known as the mitral valve.

The AV valves are attached to cords, called chordae tendineae, that are in turn attached to the papillary muscle located inside the ventricles. The muscles relax and the AV valve opens when the atrium contracts, allowing blood to flow through the valve into the ventricle. When the ventricle contracts, the papillary muscles and chordae tendineae are tensed and the valve closes, preventing blood from flowing back into the atrium.
What is the structure and function of the semilunar valves?

**Semilunar Valves**

The semilunar valves have three cusps that control the direction of blood movement. The pulmonary semilunar valve allows blood to flow from the right ventricle to the pulmonary trunk and the pulmonary circuit. The aortic semilunar valve allows blood to flow from the left ventricle to the ascending aorta and the systemic circuit.

The cusps of the semilunar valves are attached directly to the arterial walls and are not controlled by any muscles. As blood is pumped from the ventricle into the artery, the cusps open into the artery. If blood flows back toward the ventricle, the valve closes as the cusps are pushed together.

Now that we have examined blood flow to the rest of the body, let's investigate blood flow to the heart itself.

**Heart Wall**

**Structure**

*The Heart Wall And Coronary Circulation*

The heart wall is composed of three layers, of which the epicardium is the outermost layer. The next layer is called the myocardium. This thick layer of cardiac muscle and tissue surrounds the chambers of the heart, and contractions of this muscle are responsible for the pumping mechanism of the heart. The innermost layer is the endocardium, which is a thin lining that covers the myocardium and the major vessels of the heart.

**Coronary Circulation**

**Overview**

The tissue that makes up the heart wall has its own blood supply to provide nutrients and exchange wastes. This blood flow to the heart itself is called the coronary circulation. Coronary vessels encircle the heart like a crown—coronary means crown. Because of the heart wall's role in pumping blood, the heart wall requires much more oxygen, and therefore greatly increased blood flow, during exercise. How is blood supplied to the heart?

**Coronary Arteries**

As was mentioned earlier, the blood flow to the heart comes from the ascending aorta, which also supplies blood to the systemic circuit. The blood from the ascending aorta enters the right and left coronary arteries, and each of these arteries branches into two smaller arteries.

**Anastomoses**

These arteries continue to divide, and the smaller arteries connect to form a network of arteries with junctions called anastomoses. This interconnection of the coronary arteries ensures that the coronary circulation is relatively constant and independent of changes in flow from the individual coronary arteries.
**Coronary Veins**

Blood drains from this coronary network through cardiac veins to the coronary sinus, which then drains into the right atrium.

**Key Points**

- The heart is surrounded by the pericardium and the pericardial sac and is located within the center of the thorax.
- The pericardium protects and anchors the heart within the thoracic cavity.
- The heart has four chambers: two atria and two ventricles. Blood moves from the atria into the ventricles. From the left ventricle, blood is pumped into the aorta and systemic circulation. From the right ventricle, it is pumped into the pulmonary arteries and pulmonary circulation.
- The tricuspid valve is located between the right atrium and ventricle, and the bicuspid valve is situated between the left atrium and ventricle. Semilunar valves are located at the exit points of the right and left ventricles.
- The heart wall is composed of the epicardium, the myocardium, and the endocardium and is supplied with blood by the coronary arteries.