

## **Heart**

*The heart is a hollow muscular organ that is somewhat pyramid shaped and lies within the pericardium in the mediastinum . It is connected at its base to the great blood vessels but otherwise lies free within the pericardium.*

### *Surfaces of the Heart*

*The heart has three surfaces: sternocostal (anterior), diaphragmatic (inferior), and a base (posterior). It also has an apex, which is directed downward, forward, and to the left. The **sternocostal surface** is formed mainly by the right atrium and the right ventricle, which are separated from each other by the vertical atrioventricular groove . The right border is formed by the right atrium; the left border, by the left ventricle and part of the left auricle. The right ventricle is separated from the left ventricle by the anterior interventricular groove.*

*The **diaphragmatic surface** of the heart is formed mainly by the right and left ventricles separated by the posterior interventricular groove. The inferior surface of the right atrium, into which the inferior vena cava opens, also forms part of this surface. The **base of the heart**, or the posterior surface, is formed mainly by the left atrium, into which open the four pulmonary veins . The base of the heart lies opposite the apex.*

*The **apex of the heart**, formed by the left ventricle, is directed downward, forward, and to the left . It lies at the level of the fifth left intercostal space, 3.5 in. (9 cm) from the midline. In the region of the apex, the apex beat can usually be seen and palpated in the living patient. Note that the base of the heart is called the **base** because the heart is pyramid shaped; the base lies opposite the apex. The heart does not rest on its base; it rests on its diaphragmatic (inferior) surface.*

### *Borders of the Heart*

*The right border is formed by the right atrium; the left border, by the left auricle; and below, by the left ventricle . The lower border is formed mainly by the right ventricle but also by the right atrium; the apex is formed by the left ventricle. These borders are important to recognize when examining a radiograph of the heart.*

### *Chambers of the Heart*

*The heart is divided by vertical septa into four chambers: the right and left atria and the right and left ventricles. The right atrium lies anterior to the left atrium, and the right ventricle lies anterior to the left ventricle.*

*The walls of the heart are composed of cardiac muscle, the **myocardium**; covered externally with serous pericardium, the **epicardium**; and lined internally with a layer of endothelium, the **endocardium**.*

### **Right Atrium**

*The right atrium consists of a main cavity and a small out pouching, the auricle . On the outside of the heart at the junction between the right atrium and the right auricle is a vertical groove, the **sulcus terminalis**, which on the inside forms a ridge, the **crista terminalis**. The main part of the atrium that lies posterior to the ridge is smooth walled and is derived embryologically from the sinus venosus. The part of the atrium in front of the ridge is roughened or trabeculated by bundles of muscle fibers, the **musculi pectinati**, which run from the crista terminalis to the auricle. This anterior part is derived embryologically from the primitive atrium.*

#### **Openings into the Right Atrium**

*The **superior vena cava** opens into the upper part of the right atrium; it has no valve. It returns the blood to the heart from the upper half of the body. The **inferior vena cava** (larger than the superior vena cava) opens into the lower part of the right atrium; it is guarded by a rudimentary, nonfunctioning valve. It returns the blood to the heart from the lower half of the body. The **coronary sinus**, which drains most of the blood from the heart wall , opens into the right atrium between the inferior vena cava and the atrioventricular orifice. It is guarded by a rudimentary, nonfunctioning valve. The **right atrioventricular orifice** lies anterior to the inferior vena caval opening and is guarded by the tricuspid valve . Many small orifices of small veins also drain the wall of the heart and open directly into the right atrium.*

#### **Fetal Remnants**

*In addition to the rudimentary valve of the inferior vena cava are the **fossa ovalis** and **anulus ovalis**. These latter structures lie on the **atrial septum**, which separates the right atrium from the left atrium . The fossa ovalis is a shallow depression, which is the site of the **foramen ovale** in the fetus . The anulus ovalis forms the upper margin of the fossa. The floor of the fossa represents the persistent septum primum of the heart of the embryo, and the anulus is formed from the lower edge of the septum secundum . The interior of the left atrium is smooth, but the left auricle possesses muscular ridges as in the right auricle.*

#### **Openings into the Left Atrium**

*The four pulmonary veins, two from each lung, open through the posterior wall and have no valves. The left atrioventricular orifice is guarded by the mitral valve.*

### **Left Ventricle**

*The left ventricle communicates with the left atrium through the atrioventricular orifice and with the aorta through the aortic orifice. The walls of the left ventricle are three times thicker than those of the right ventricle. (The left intraventricular blood pressure is six times higher than that inside the right ventricle.) In cross section, the left ventricle is circular; the right is crescentic because of the bulging of the ventricular septum into the cavity of the right ventricle. There are well developed trabeculae carneae, two large papillary muscles, but no moderator band. The part of the ventricle below the aortic orifice is called the **aortic vestibule**. The **mitral valve** guards the atrioventricular orifice. It consists of two cusps, one anterior and one posterior, which have a structure similar to that of the cusps of the tricuspid valve. The anterior cusp is the larger and intervenes between the atrioventricular and aortic orifices. The attachment of the chordae tendineae to the cusps and the papillary muscles is similar to that of the tricuspid valve. The **aortic valve** guards the aortic orifice and is precisely similar in structure to the pulmonary valve. One cusp is situated on the anterior wall (right cusp) and two are located on the posterior wall (left and posterior cusps). Behind each cusp, the aortic wall bulges to form an **aortic sinus**. The anterior aortic sinus gives origin to the right coronary artery, and the left posterior sinus gives origin to the left coronary artery.*

#### *Structure of the Heart*

*The walls of the heart are composed of a thick layer of cardiac muscle, the myocardium, covered externally by the epicardium and lined internally by the endocardium. The atrial portion of the heart has relatively thin walls and is divided by the **atrial (interatrial) septum** into the right and left atria. The septum runs from the anterior wall of the heart backward and to the right. The ventricular portion of the heart has thick walls and is divided by the **ventricular (interventricular) septum** into the right and left ventricles. The septum is placed obliquely, with one surface facing forward and to the right and the other facing backward and to the left. Its position is indicated on the surface of the heart by the anterior and posterior interventricular grooves. The lower part of the septum is thick and formed of muscle. The smaller upper part of the septum is thin and membranous and attached to the fibrous skeleton. The so-called **skeleton of the heart** consists of fibrous rings that surround the atrioventricular, pulmonary, and aortic orifices and are continuous with the membranous upper part of the ventricular septum. The fibrous rings around the atrioventricular orifices separate the muscular walls of the atria from those of the ventricles but provide attachment for the*

*muscle fibers. The fibrous rings support the bases of the valve cusps and prevent the valves from stretching and becoming incompetent. The skeleton of the heart forms the basis of electrical discontinuity between the atria and the ventricles.*

### **Conducting System of the Heart**

*The normal heart contracts rhythmically at about 70 to 90 beats per minute in the resting adult. The rhythmic contractile process originates spontaneously in the conducting system and the impulse travels to different regions of the heart, so the atria contract first and together, to be followed later by the contractions of both ventricles together. The slight delay in the passage of the impulse from the atria to the ventricles allows time for the atria to empty their blood into the ventricles before the ventricles contract. The conducting system of the heart consists of specialized cardiac muscle present in the **sinuatrial node**, the **atrioventricular node**, the **atrioventricular bundle** and its right and left terminal branches, and the subendocardial plexus of **Purkinje fibers** (specialized cardiac muscle fibers that form the conducting system of the heart).*

### **Sinuatrial Node**

*The sinuatrial node is located in the wall of the right atrium in the upper part of the sulcus terminalis just to the right of the opening of the superior vena cava . The node spontaneously gives origin to rhythmic electrical impulses that spread in all directions through the cardiac muscle of the atria and cause the muscle to contract.*

### **Atrioventricular Node**

*The atrioventricular node is strategically placed on the lower part of the atrial septum just above the attachment of the septal cusp of the tricuspid valve . From it, the cardiac impulse is conducted to the ventricles by the atrioventricular bundle. The atrioventricular node is stimulated by the excitation wave as it passes through the atrial myocardium. The speed of conduction of the cardiac impulse through the atrioventricular node (about 0.11 seconds) allows sufficient time for the atria to empty their blood into the ventricles before the ventricles start to contract.*

### **Atrioventricular Bundle**

*The atrioventricular bundle (bundle of His) is the only pathway of cardiac muscle that connects the myocardium of the atria and the myocardium of the ventricles and is thus the only route along which the cardiac impulse can travel from the atria to the ventricles . The bundle*

*descends through the fibrous skeleton of the heart. The atrioventricular bundle then descends behind the septal cusp of the tricuspid valve to reach the inferior border of the membranous part of the ventricular septum. At the upper border of the muscular part of the septum, it divides into two branches, one for each ventricle. The right bundle branch (RBB) passes down on the right side of the ventricular septum to reach the moderator band, where it crosses to the anterior wall of the right ventricle. Here, it becomes continuous with the fibers of the Purkinje plexus .*

*The left bundle branch (LBB) pierces the septum and passes down on its left side beneath the endocardium. It usually divides into two branches (anterior and posterior), which eventually become continuous with the fibers of the Purkinje plexus of the left ventricle. It is thus seen that the conducting system of the heart is responsible not only for generating rhythmic cardiac impulses, but also for conducting these impulses rapidly throughout the myocardium of the heart so that the different chambers contract in a coordinated and efficient manner. The activities of the conducting system can be influenced by the autonomic nerve supply to the heart. The parasympathetic nerves slow the rhythm and diminish the rate of conduction of the impulse; the sympathetic nerves have the opposite effect.*

#### **Internodal Conduction Paths\***

*Impulses from the sinoatrial node have been shown to travel to the atrioventricular node more rapidly than they can travel by passing along the ordinary myocardium. This phenomenon has been explained by the description of special pathways in the atrial wall , which have a structure consisting of a mixture of Purkinje fibers and ordinary cardiac muscle cells. The **anterior internodal pathway** leaves the anterior end of the sinoatrial node and passes anterior to the superior vena caval opening. It descends on the atrial septum and ends in the atrioventricular node. The **middle internodal pathway** leaves the posterior end of the sinoatrial node and passes posterior to the superior vena caval opening. It descends on the atrial septum to the atrioventricular node. The **posterior internodal pathway** leaves the posterior part of the sinoatrial node and descends through the crista terminalis and the valve of the inferior vena cava to the atrioventricular node.*

#### **The Arterial Supply of the Heart**

*The arterial supply of the heart is provided by the right and left coronary arteries, which arise from the ascending aorta immediately above the aortic valve . The coronary arteries and their major branches are*



*distributed over the surface of the heart, lying within subepicardial connective tissue. The **right coronary artery** arises from the anterior aortic sinus of the ascending aorta and runs forward between the pulmonary trunk and the right auricle . It descends almost vertically in the right atrioventricular groove, and at the inferior border of the heart it continues posteriorly along the atrioventricular groove to anastomose with the left coronary artery in the posterior interventricular groove. The following branches from the right coronary artery supply the right atrium and right ventricle and parts of the left atrium and left ventricle and the atrioventricular septum.*

### **Branches**

- 1. The **right conus artery** supplies the anterior surface of the pulmonary conus (infundibulum of the right ventricle) and the upper part of the anterior wall of the right ventricle.*
- 2. The **anterior ventricular branches** are two or three in number and supply the anterior surface of the right ventricle. The **marginal branch** is the largest and runs along the lower margin of the costal surface to reach the apex.*
- 3. The **posterior ventricular branches** are usually two in number and supply the diaphragmatic surface of the right ventricle.*
- 4. The **posterior interventricular (descending) artery** runs toward the apex in the posterior interventricular groove. It gives off branches to the right and left ventricles, including its inferior wall. It supplies branches to the posterior part of the ventricular septum but not to the apical part, which receives its supply from the anterior interventricular branch of the left coronary artery. A large septal branch supplies the **atrioventricular node**. In 10% of individuals, the posterior interventricular artery is replaced by a branch from the left coronary artery.*
- 5. The **atrial branches** supply the anterior and lateral surfaces of the right atrium. One branch supplies the posterior surface of both the right and left atria. The **artery of the sinuatrial node** supplies the node and the right and left atria; in 35% of individuals it arises from the left coronary artery. The **left coronary artery**, which is usually larger than the right coronary artery, supplies the major part of the heart, including the greater part of the left atrium, left ventricle, and ventricular septum. It arises from the left posterior aortic sinus of the ascending aorta and passes forward between the pulmonary trunk and the left auricle . It then enters the atrioventricular groove and divides into an anterior interventricular branch and a circumflex branch.*

## **Branches**

### **1. The anterior interventricular (descending) branch**

*runs downward in the anterior interventricular groove to the apex of the heart . In most individuals, it then passes around the apex of the heart to enter the posterior interventricular groove and anastomoses with the terminal branches of the right coronary artery. In one third of individuals, it ends at the apex of the heart. The anterior interventricular branch supplies the right and left ventricles with numerous branches that also supply the anterior part of the ventricular septum. One of these ventricular branches (**left diagonal artery**) may arise directly from the trunk of the left coronary artery. A small **left conus artery** supplies the pulmonary conus.*

**2. The circumflex artery** is the same size as the anteriorinterventricular artery . It winds around the left margin of the heart in the atrioventricular groove. A **left marginal artery** is a large branch that supplies the left margin of the left ventricle down to the apex. **Anterior ventricular** and **posterior ventricular branches** supply the left ventricle. **Atrial branches** supply the left atrium.

### **Arterial Supply to the Conducting System**

*The sinuatrial node is usually supplied by the right but sometimes by the left coronary artery. The atrioventricular node and the atrioventricular bundle are supplied by the right coronary artery. The RBB of the atrioventricular bundle is supplied by the left coronary artery; the LBB is supplied by the right and left coronary arterie .*