

Anatomy of the heart

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Abstract

The heart, enveloped in the fibrous pericardium, occupies the middle mediastinum. This article describes the essentials of external and internal cardiac anatomy, and highlights those aspects of cardiac functional anatomy that are of particular relevance to clinical cardiac examination.

Keywords Atrium; cardiac chambers; cardiac conduction; cardiac tamponade; cardiac valves; coronary arteries; myocardium; pericardial cavity; pericardium; ventricle

The heart is a hollow, fibromuscular organ in the shape of an irregular cone. Situated between the right and left pleural sacs, in the middle mediastinum, its long axis lies obliquely along a line running from the left mid-clavicular line anteriorly, to the right mid-scapular line posteriorly. One-third of the heart lies to the right of the median (sagittal) plane of the body and two-thirds to the left of this plane.

Pericardium

The heart is enclosed in the pericardium, a fibroserous sac comprising three concentric layers. The outermost layer, termed the fibrous pericardium, is a dense, tough and inelastic fibrous layer. It is blended inferiorly with the central tendinous portion of the diaphragm, while anteriorly it is attached to the posterior surface of the sternum by bands of connective tissue termed sternopericardial ligaments. Within the fibrous pericardium is the serous pericardium, which consists of two layers (Figure 1) the outer of these two layers is firmly applied to the inner surface of the fibrous pericardium, and is termed the parietal layer. This layer is reflected around the roots of the great vessels to become continuous with the visceral layer (also called the epicardium), which covers the surface of the heart, and is firmly applied to it. Between the parietal and visceral layers of the serous pericardium is the pericardial cavity, which contains a thin film of fluid. This film enables the pulsating heart to glide frictionlessly within the pericardium. The pericardial cavity has two prominent recesses: the transverse sinus and the oblique sinus. The latter, situated behind the left atrium, is limited on the right by the right pulmonary veins and inferior vena cava, and on the left by the left pulmonary veins. The transverse sinus lies behind the roots of the aorta and pulmonary trunk, and is limited posteriorly by the atrial chambers.

The fibrous pericardium fuses with the walls of the great vessels (superior and inferior vena cavae, ascending aorta, pulmonary trunk and the four pulmonary veins) where these vessels perforate the fibrous pericardium. Consequently, fluid collections in the pericardial cavity (e.g. haemopericardium) have no natural route of escape and, if sufficiently large, may hinder cardiac

expansion and thereby compromise cardiac output. This potentially life-threatening phenomenon is referred to as cardiac tamponade.

Surfaces of the heart

The heart may be described as possessing an anterior (or sternocostal) surface, an inferior (or diaphragmatic) surface, a left surface (also referred to as the left or 'obtuse' margin/border), a blunt right border and an inferior border (also called the 'acute' margin/border). The inferior border is the edge along which the anterior surface meets the diaphragmatic surface of the heart.

In addition, the heart possesses a posterior surface (also termed the base of the heart) and a rounded 'apex' (the area where the anterior, inferior and left surfaces meet). The upper limit of the heart corresponds to the upper margins of the right and left atria, and may be referred to as the superior border.

The heart functions as a self-adjusting 'double pump':

- The pulmonary pump or 'right heart', comprising the right atrium and right ventricle, is a relatively low-pressure system.
- The systemic pump or 'left heart', comprising the left atrium and left ventricle, is a high-pressure system.

The two pump systems are arranged in series, with the pulmonary vascular bed interposed between them. Topographically, the 'right heart' lies in front of the 'left heart'.

The posterior surface of the heart (base of the heart) is made up, almost entirely, of the posterior surface of the left atrium, with the left ventricle and right atrium making minor contributions to this surface. The anterior surface of the heart (Figure 1) is made up largely of the right ventricle. However, the right atrium (including its appendage) and the left ventricle and left atrial appendage make relatively small contributions to this surface of the heart. The atrioventricular groove runs vertically on this surface to reach the inferior border, and then turns to run anteroposteriorly on the inferior surface of the heart. Also evident on the anterior surface just medial (and almost parallel) to the left heart border is the anterior interventricular sulcus. The inferior surface of the heart consists of the floor of the right atrium receiving the inferior vena cava, the atrioventricular sulcus and, to the left of this sulcus, the inferior walls of the right and left ventricles, the latter making the greater contribution on this surface. The left surface is made up almost entirely of the left ventricle, whereas the posterior surface is made up almost entirely of the left atrium receiving the right and left pulmonary veins.

The two-dimensional cardiac silhouette as seen on a chest radiograph (anteroposterior view) occupies a trapezoidal area within the following four borders:

- Right heart border (made up entirely of the lateral edge of the right atrium).
- Inferior heart border (made up mostly of the lower edge of right ventricle, with a contribution from the left ventricle at the left extremity of this border).
- Left heart border (made up of the lateral edge of the left ventricle with the left atrial appendage making a contribution to the upper end of this border).
- Superior heart border (somewhat oblique as it runs across the roots of the aorta and pulmonary trunk).

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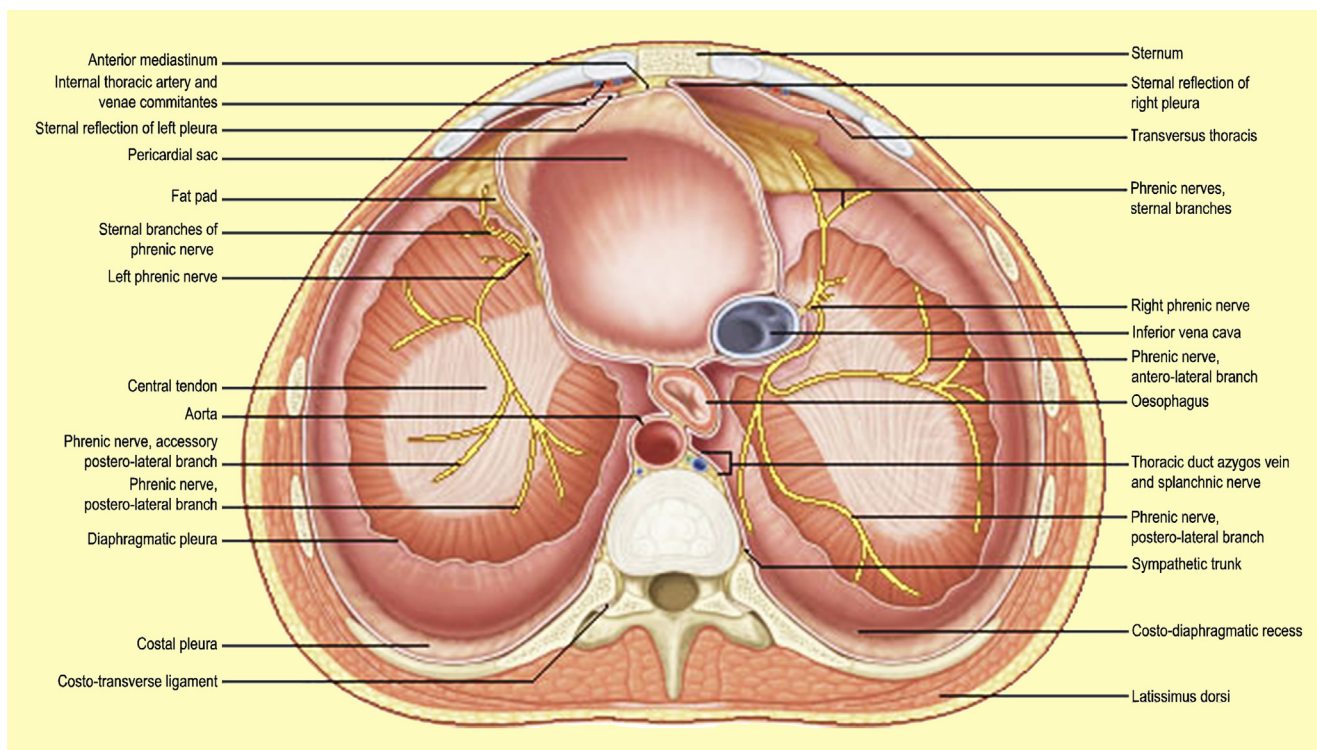


Figure 1 The opened pericardium seen from above

Surface marking of the cardiac outline

The right heart border may be depicted by a line running from the lower border of the third right costal cartilage to the lower border of the sixth right costal cartilage slightly lateral to the right sternal edge.

The inferior border of the heart is indicated by a line running from the lower end of the right heart border to the cardiac apex which is approximately in the fifth left intercostal space in the mid-clavicular line.

The left heart border runs upwards and medially from the cardiac apex to the lower border of the second left costal cartilage about 2 cm from the left sternal edge. A line joining the upper ends of the right and left heart borders represents the superior border of the heart.

Cardiac chambers

The heart possesses a 'fibrous skeleton' that provides anchorage for the myocardium of the cardiac chambers and for the cusps of the heart valves. The fibrous skeleton of the heart, composed of dense collagen, is a conjunction of four fibrous rings (corresponding to the right and left atrioventricular orifices, and the orifices of the pulmonary trunk and aorta) and the contiguous parts of the interatrial and interventricular septa.

The right atrium has a predominantly smooth interior. Part of the anterior wall and the atrial appendage have trabeculated interiors. A prominent vertical ridge on the inner aspect of the anterior wall is termed the crista terminalis. A corresponding

groove on the exterior is termed the sulcus terminalis. The posterior wall of the right atrium is the interatrial septum.

The openings of the superior and inferior vena cavae are on the roof and floor, respectively, of the right atrium. To the left of the inferior vena caval opening is the opening of the coronary sinus, which transmits most of the venous return of the heart to the right atrium. To the left of the opening of the coronary sinus is the tricuspid opening (guarded by the tricuspid valve) leading to the right ventricle. Above the opening of the coronary sinus, in the adjacent part of the interatrial septum, is the atrioventricular node. The junction of the sulcus terminalis and superior vena cava marks the location of the sinoatrial node.

The left atrium has smooth walls except within the left atrial appendage. Entering the posterior wall of the left atrium on either side are the corresponding upper and lower pulmonary veins. The inferior part of the left atrium has the mitral opening (guarded by the mitral valve) leading to the left ventricle.

The inner aspects of the walls of **the right and left ventricles** show prominent muscular ridges, termed trabeculae. In both chambers, some of these trabeculae form papillary muscles, which are connected to the cusps of the corresponding atrioventricular valve (tricuspid/mitral) by inelastic cords called chordae tendinae.

The outflow tract of the right ventricle is called the infundibulum. Its junction with the pulmonary trunk is guarded by the pulmonary valve. The outflow tract of the left ventricle leads to the aortic root, with the aortic valve situated at the junction between the two.

The left ventricular wall is three times as thick as the wall of the right ventricle. This reflects the significantly higher

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