

Heart

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Heart (cor) is a muscle organ with four chambers that acts as a continuously operating pump. It drives the blood through the blood vessels to all parts of the body and thus allows nutrition and metabolism in the tissues

Heart anatomy

The heart is placed behind the sternum in the mediastinum, two thirds to the left of the midline and one third to the right. **The weight of the heart** averages around **300-350 g** in men, and in women it weighs around **250-300 g**.^[1] An increase in the heart's weight above 400 g in men and above 350 g in women is called hypertrophy.^[1] The heart can hypertrophy in various pathological conditions or also in athletes. The whole muscle organ is enclosed in a envelope called the **pericardium** with a serous cavity.

General anatomy of the heart

Heart position

The heart muscle has the shape of an irregular cone and it is oriented ventrolaterally to the left with its tip (the longitudinal axis of the heart points from the mouth of the superior vena cava from top to right from back to front to left). The tip of the cone is projected into the 5th intercostal space near the medioclavicular line. The position of the tip changes with age and respiratory activity (approximately one intercostal space). In children it is moved one intercostal space higher and laterally, in older people it is located in the 6th intercostal space.

The projection of the heart is presented by four main points:

1. **Point A:** on the right in the 2nd intercostal space, 1 cm from the sternum.
 2. **Point T:** located in the 5th intercostal space, at the right edge of the sternum, there is an auscultation point for the tricuspid valve.
 3. **Point M:** in the 5th intercostal space, internally from the medioclavicular line, auscultation point for the mitral valve.
 4. **Point P:** on the left in the 2nd intercostal space, 2 cm from the sternum margin.
- By connecting these points, we obtain the approximate dimensions of the cardiac shadow.

Overall the **position of the heart** is **individually** variable, depending on breathing, diaphragm position, chest shape, somatotype, etc. In the case of a wide and short chest, the position of the heart is more transverse - the longitudinal axis of the heart forms a smaller angle with the transverse plane. On the other hand, if there is a case of a long and narrow chest, the heart is placed more longitudinally - the longitudinal axis forms a larger angle with the transverse plane.

Heart description

At heart we can describe:

- **basis cordis** - the cranial part with the atria, the main vessels enter and exit here;
- **apex cordis** - tip of the heart;
- **facies sternocostalis (anterior)** - anterior arched surface, facing the sternum and ribs;
- **facies diaphragmatica (inferior)** - side facing the diaphragm;
- **facies pulmonalis** - sometimes referred to as the left area facing the lungs;
- **margo acutus** - the right edge of the heart in a sharp boundary line;
- **margo obtusus** - left, rounded edge of the heart.

The atria and ventricles are macroscopically separated from each other by:

- **sulcus coronarius** - separates atria from ventricles at the base of heart, the main coronary vessels are located there;
- **septum interatriale et septum interventriculare** - are visible as cardiac septums;
- **sulcus interventricularis anterior et posterior** - visible depressions separating the ventricles in front and back.

Muscle thickness

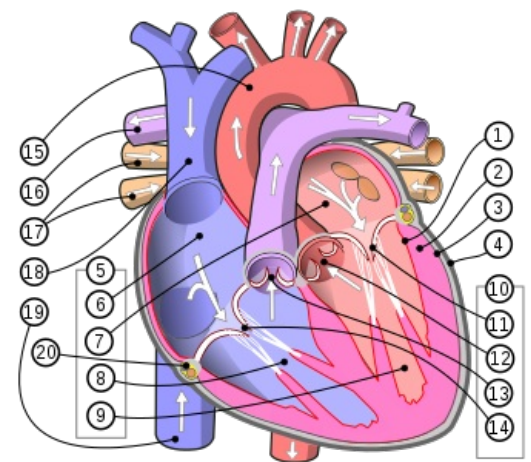
Cardiac muscle thickness varies in specific places:

- Atria = 2-2,5 mm;
- Right ventricle = 3-4,5 mm;
- Left ventricle = 12-14 mm;
- Interventricular septum = 12,5-15 mm. ^[1]

Heart histology

From a histological point of view, the heart wall is made up of **3 layers**, they are the endocardium, myocardium and epicardium.

Endocardium



Labeled diagram of heart: 1 - endocardium; 2 - myocardium; 3 - epicardium; 4 - pericardium; 5 - heart cavities; 6 - right atrium; 7 - left atrium; 8 - right ventricle; 9 - left ventricle; 10 - heart valves; 11 - mitral valve; 12 - aortic valve; 13 - pulmonary valve; 14 - tricuspid valve; 15 - aortic arch; 16 - right pulmonary artery; 17 - right pulmonary veins; 18 - superior vena cava; 19 - inferior vena cava; 20 - atrioventricular septum

Endocardium (inner layer; *tunica intima*) lines the heart cavity, is in contact with the flowing blood, smoothly changes into the tunic of the vascular intima, forms the **heart valves**. It consists of 4 layers:

1. **endothelium** (endothelial cells);
2. **subendothelium** (collagen ligament);
3. **elastic-muscular layer** (collagen and elastic ligament, smooth muscle cells; this layer is especially strong in the atria);
4. **subendocardium** (a sparse connective tissue, in which you can find the electrical conduction system of the heart).

Myocardium

The **myocardium** (tunica media) is cardiac muscle that ensures regular heart contractions . It is the thickest part of the heart wall, which it forms together with the endocardium and epicardium . The strongest myocardium is found in the left ventricle, where the blood pressure is the highest, and where oxygenated blood is ejected into the systemic circulation.

Structure

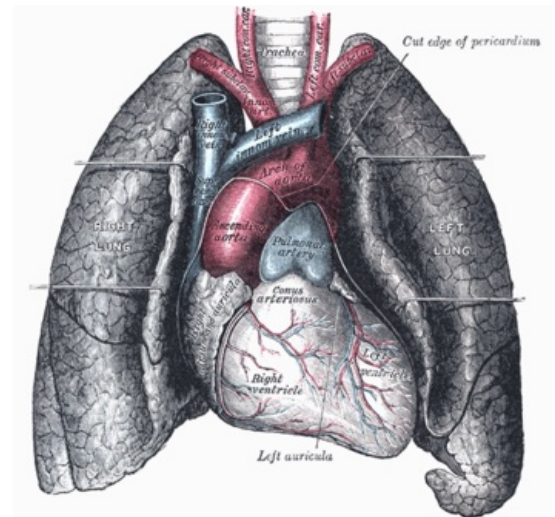
The basic building block of the heart muscle is the cardiomyocyte. These are Y-shaped muscle cells. The cell nuclei are located in the center of the cell and they are elongated. The cell nucleus may contain one to two nucleoli

Properties

Cardiac muscle tissue combines the properties of skeletal and smooth muscle. It consists of striated cardiac muscle tissue, which **is not controllable by will** (it is not subject to free control - involuntary).

It is innervated by the autonomic nervous system, which controls the frequency of contractions. The contractions arise spontaneously in the cardiac conduction system (cardiac automation).

The myocardium is nourished by coronary arteries that arise directly from the aorta. If it is not adequately supplied with nutrients, complications occur in the form of diseases, especially myocardial infarction and coronary heart disease.



Heart in mediastinum



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Epicardium (<https://www.wikilectures.eu/index.php?title=Myocardium&action=edit>)
 [edit part (<https://www.wikilectures.eu/index.php?title=Epicardium&action=edit>)]

Epicardium (outer layer of the heart wall; tunica serosa) is the mesothelial lining forming the visceral leaf pericardium. It is furthest from the heart cavity, communicating with about 50 ml of pericardial fluid. Coronary arteries takes place in the subepicardium.

Heart chambers

As blood passes through the heart, it flows through the four cavities - the right atrium, the right ventricle, the left atrium and the left ventricle. The individual cavities in the right and left heart are separated by valves that prevent the back flow of blood.

Right atrium (*atrium dextrum*)

The *vena cava superior* opens into the right atrium at the back from above, in **ostium venae cavae superioris**. Vena cava inferior comes from below in *ostium venae cavae inferioris*. The point of entry of both hollow veins is called "sinus venarum cavarum". The *Sulcus terminalis* is a shallow depression to the right of the mouth of both veins, separating them from the rest of the vestibule. On the hollow side, it corresponds to the "crista terminalis", which is supported by a strip of muscle.

The blood flowing from the inferior vena cava to the heart is directed by the walls into the **valvula venae cavae inferioris**, analogously the blood from vena cava superior is directed in the other way by the *tuberculum intervenosum*.

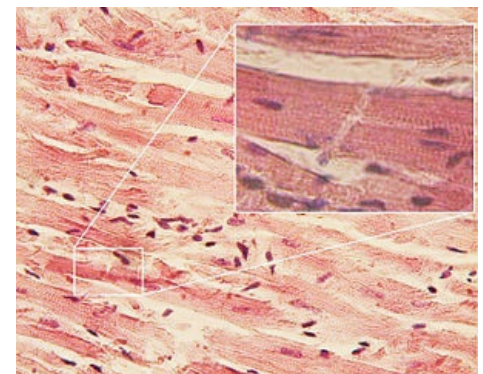
The right atrium is the area in front of the sinus venarum cavarum and contains several formations:

- **auricula dextra** - right ear, which is a pin-shaped protrusion visible on the sternocostal surface of the heart;
- **musculi pectinati** - the muscle ridges that are most prominent in the auricule;
- **ostium sinus coronarii** - the entrance of the main stem of the collecting veins of the heart into the right atrium, partially covered by *valvula sinus coronarii* ;
 - on the inner surface there are other visible openings, which serve as entrances for smaller collecting veins of the heart.

The medial wall is formed by the **septum interatriale**, with a noticeable **fossa ovalis**. During the embryonic development, it served as a transitional link between the two atria. The septum has fibrous, thinned part without muscle - *pars membranacea septi*.

Right ventricle (*ventriculus dexter*)

Inflow part



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The inflow part begins in the **ostium atrioventriculare dextrum** with a triple valve (*valva atrioventricularis dextra*; *valva tricuspidalis*). We distinguish three tips on it - *cuspides anterior, posterior et septalis*. Against the tips *musculi papillares* are stretched, and with their pull that they generate through the *chordae tendinae*, they prevent the valve from tipping into the atrium. In the right ventricle, the most significant are *m. papillaris anterior et posterior*, and in variable quantities are also *mm. papillares septales*.

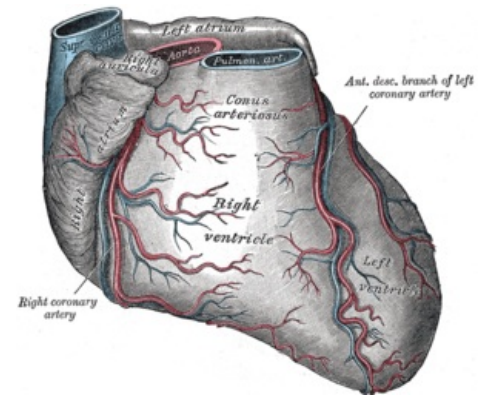
Inflow part ends in **ostium trunci pulmonalis** with semilunar valves. (*valva trunci pulmonalis*)

- On the walls there are *trabeculae carneae ventriculi dextri*, which are muscle trabeculae similar to *musculi pectinati* in the atria. From the ventricular septum to the base of the anterior papillary muscle, there is a muscle bundle of the *trabecula septomarginalis* that contains part of cardiac conduction system.

Outflow part

No trabeculae are present in this part, so the smooth part is called *pars glabra*. We distinguish the following parts:

- conus arteriosus** is the name for outflow part cranially in the direction of **ostium trunci pulmonalis**, it has a conical shape;
- ostium trunci pulmonalis** has a valve **valva trunci pulmonalis**, which consist of three *valvulae semilunares*, semilunar valves;
 - valvula semilunaris anterior, dextra et sinistra* - semilunar lamellas in the shape of a swallow's nest;
 - The *lunula* is a the thinned edge, the middle of each lamella contains *nodulus valvulae semilunaris*, which ensures the closure of the center of the valve.



Heart from the right side

Left atrium (atrium sinistrum)

In the left atrium, we distinguish the following units:

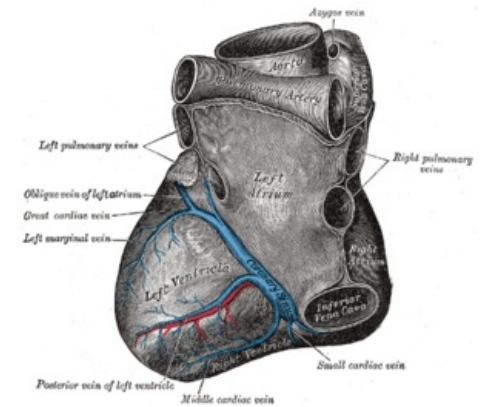
- ostia venarum pulmonalium** - the mouth of the pulmonary veins, usually two on the left and two on the right, without valves
- auricula sinistra** - left ear containing the same as the right ear *musculi pectinati*;
- septum interatriale** - atrial septum, in the place of the right-hand *fossa ovalis* is referred to as *valvula foraminis ovalis*;
- ostium atrioventriculare sinistrum** is the mouth of the left atrium into the left ventricle provided with a double valve (*valva atrioventricularis sinistra*; *valva mitralis* or *valva bicuspidalis*).

Left ventricle (ventriculus sinister)

The left ventricle is round with a thicker muscle wall in cross section (approximately three times the mass of the muscle compared to the right ventricle).

The Inflow part is larger than the right ventricle, from the *ostium atrioventriculare sinistrum* forward down to the apex and to the anterior wall of the ventricle. We distinguish in it:

- ostium atrioventriculare sinistrum** - part of *valva atrioventricularis sinistra (valva mitralis)*;
 - valva has two main points - *cuspides anterior et posterior*;
 - two papillary muscles are stretched to the tips - *m. papillaris anterior et posterior*;
 - again by pulling over the *chordae tendinae* they ensure the correct position of the the valve;
- trabeculae carneae** - thicker and with larger depressions than in the right ventricle;
 - functionally, during systole of the chamber, they fit tightly together and fill the cavity of the inflow part, which thanks to this mechanism empties completely.




Heart from the right side

The Outflow part is shorter than in the right heart a it is located more ventromedially from *ostium atrioventriculare sinistrum*, it points caudally. We distinguish in it:

- ostium aortae** - right next to the atrioventricular orifice, more ventromedially located
 - contains *valva aortae* consisting of three crescent-shaped valves (*valvulae semilunares*);
 - valva semilunaris dextra, sinistra et posterior*;
 - analogous to the pulmonary valve, they contain "lunulae" and "nodules" with the same function;
- sinus aortae** is the dilated beginning of the aorta above each of the three lamellae of the valve, from which the two main coronary arteries branch (see below).

Seen from the left ventricle through the septum interventricularis, we can see a fibrous, thinned septal site, referred to as the *pars membranacea septi interventricularis*. That means, that the "pars membranacea" is located between the inflow part of the right ventricle and the outflow part of the left ventricle.

Coronary circulation

 For more information see [Coronary circulation](#).

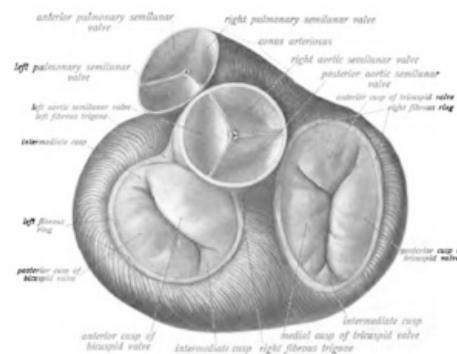
The heart is supplied by two main coronary arteries, extending as the first branches of the aorta. The venous return is provided by the veins merging into the trunk **sinus coronarius**, leading to the right atrium of the heart.

Cardiac skeleton

Cardiac skeleton it is made of dense fibrous ligaments which is attached to the myocardium together with all the heart valves. The skeleton **electrically separates** the myocardium of the atria from the myocardium of ventricles (the only link between the atrial myocardium and the ventricular myocardium is the so-called **Bundle of His** passing through the trigonum fibrosum dextrum). It consist of several parts:

- **Anuli fibrosi** - four fibrous rings around the heart valves:
 - **anulus fibrosus dexter** - at the right atrial orifice with a tricuspid valve;
 - **anulus fibrosus sinister** - at the left atrial orifice with mitral valve;
 - **anulus aorticus** - semilunar valve ring;
 - **anulus trunci pulmonalis** - ring of the semilunar pulmonary valve.

These rings are interconnected by the fibrous structures **trigonum fibrosum dextrum** (between anulus dexter, sinister and aorticus) and **trigonum fibrosum sinisterum** (between anulus sinister and aorticus). The pars membranacea septi is connected to the right trigon .

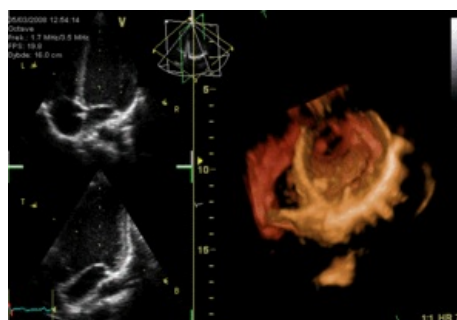


View of the cardiac skeleton and heart valves

Heart valves

Heart valves are valves that ensure one-sided flow of blood in the heart. **They are not innervated** and they are **avascular** (they open and close based on a pressure gradient). From a histological point of view, these are endocardial duplications. They are formed by an internal fibrous plate (collagen and elastic fibers), on the surface they are covered by endothelium. They are connected to the fibrous rings of the heart skeleton. In the heart we find 4 heart valves, they are:

1. **tricuspid valve** (valva atrioventricularis dextra seu tricuspidalis) - between the right atrium and the right ventricle;
2. **pulmonary valve** (valva trunci pulmonalis) - between the right ventricle and the pulmonary artery;
3. **mitral valve** (valva atrioventricularis sinistra seu bicuspidalis seu mitralis) - between left atrium and left ventricle;
4. **aortic valve** (valva aortae) - between the left ventricle and the aorta.



2D and 3D image of the heart taken by an echocardiograph. The 2D image shows the tricuspid and mitral valve (top) and the aortic and mitral valve (bottom).

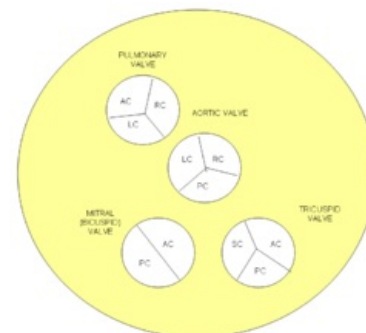
Heart blood flow

Clinically, the heart is divided into **left heart** and **right heart**. The left heart includes the left atrium and left ventricle, the right heart contains the right atrium and right ventricle. The right and left hearts work together. We distinguish between **small (pulmonary) circulation** and **large (body) circulation**.

Right heart

Blood flows from **superior and inferior cava** to the right atrium. *Blood flows through the atrium to the **tricuspid valve**, through which it enters the **right ventricle**. In the wall of the right atrium is the first part of the **heart conduction system**, which creates excitement for regular heart contractions. Specifically, the **SA and AV node**.*

Blood flows from the **right atrium** through **tricuspid valve**. In the ventricle, it first flows through the inflow part (**trabeculae carnae**) and after it continues to the outflow part (**conus arteriosus**). Through **pulmonary valve** it flows to **pulmonary artery** and its branches to the lungs, in which **the exchange of blood gases** takes place. The right ventricle pumps blood at low pressure (approximately 20 mmHg).



Scheme of heart valves

Left heart

From the lungs , oxygenated blood enters the left atrium through four pulmonary veins . It flows through the mitral (bicuspid) valve and enters the left ventricle .

Blood flows from the **left atrium** through **mitral valve**. In the left ventricle it first flows through the inflow part (again composed of **trabeculae carnae**) and then it passes into the **outflow part** (represented by **vestibulum aortae**). Through the **aortic valve** it flows into the **aorta ascendens** and its branches into the whole body. The left ventricle pumps blood under **high pressure** within the systemic circulation (at about 120 mmHg).

Cardiac conduction system

For more information see *Cardiac conduction system*.

This system ensures the generation of action potentials for myocardial work independently of nerve connections - cardiac myogenicity.

Lymphatic vessels of the heart


For more information see *Lymphatic vessels of the heart*.

The lymph vessels of the heart begin with three networks:

- subendocardial;
- myocardial;
- subepicardial

During diastole, lymph flows from the subendocardial plexus to the myocardial network and from there to the subepicardial network during systole. The right and left collectors of the heart are then collected from the subepicardial network.

Chest X-Ray

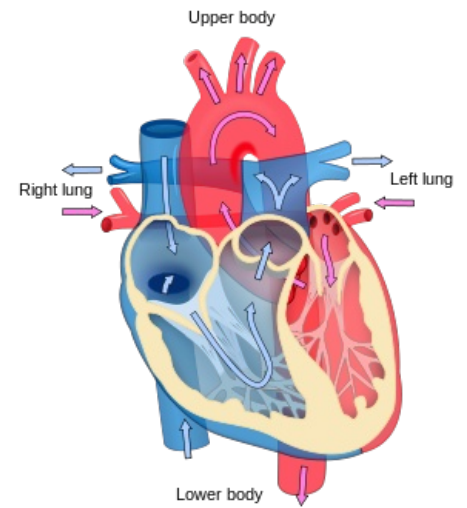
 For more information see *Cardiac silhouette*.

Links

Related articles

- Pericardium
- Cardiac conduction system
- Vascular supply of the heart
- X-ray image of the heart
- Congenital heart defects
- Cor pulmonale
- Causes of heart and blood vessel infections

https://www.wikilectures.eu/index.php?title=Lymphatic_vessels_of_the_heart&action=edit]]



Mechanism of blood flow through the heart. Blue is deoxygenated blood, red is oxygenated blood.

External sources

- Srdce (česká wikipedie)
- Heart (anglická wikipedie)
- Gray's anatomy - heart (<https://www.yahoo.com/>)

Sources

- SEDMERA, David. *Srdce* [online]. [cit. 13.10.2011]. <<https://el.lf1.cuni.cz/lekls08>>.

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