The Human Anatomy of Heart: A Review literature

***Mohammad Ali Ansari [1]**

[1] * Professor and HOD,

Department of Tashreeh-ul-Badan (Anatomy),

Inamdar Unani Medical College and Hospital, Kalaburagi

profmohammadaliansari@gmail.com

Abstract:

The heart is a complex organ that pumps blood through the body with an intricate system of muscle layers, chambers, valves and nodes. It has its own circulation system and receives electric impulses that make it contract and relax, which triggers a sequence of events forming the cardiac cycle. A solid and methodical understanding of how the heart works is key to understanding what can go wrong with it. This first article in a two-part series covers anatomy and physiology, and the second part discusses pathophysiology. The human heart is a finely-tuned instrument that serves the whole body. It is a muscular organ around the size of a closed fist, and it sits in the chest, slightly to the left of center. The heart beats around 100,000 times a day, pumping approximately 8 pints of blood throughout the body 24/7. This delivers oxygen- and nutrient-rich blood to tissues and organs and carries away waste. The heart sends deoxygenated blood to the lungs, where the blood loads up with oxygen and unloads carbon dioxide, a waste product of metabolism. Together, the heart, blood, and blood vessels arteries, capillaries, and veins make up the circulatory system. In this article, we explore the structure of the heart, how it pumps blood around the body, and the electrical system that controls it.

Keywords: conventional heart anatomy; Atria and ventricles, Cardiac valves, Diastole, systole, and blood pressure

1. Introduction

The heart is the key organ of the cardiovascular system – the body's transport system for blood. A muscle that contracts rhythmically and autonomously, it works in conjunction with an extensive network of blood vessels running throughout the body. Basically, the heart is a pump ensuring the continuous circulation of blood in the body. This article describes the heart's anatomy and physiology. Cardiac anatomy is usually taught to medical students on the basis of examination of the cadaveric hearts opened and studied in the dissecting room. This approach, despite multiple limitations, has endured over the passage of time. Such dissection of the heart, due to the complex three-dimensional interrelations of its component parts, is known to be challenging. It is also well recognized that the elements of anatomy taught in the first year of the medical curriculum do not always instill a lasting knowledge. Detailed knowledge of the structure and location of the cardiac components, nonetheless, is essential information for those diagnosing and treating cardiac disease. With the intention of improving the initial acquisition of this knowledge, we have recently emphasized the value of virtual reconstructions of datasets obtained in the clinical setting. When using a similar approach, medical students were shown not only to enjoy the exposure to three-dimensional reconstructions, but also significantly to improve their acquisition of the details of cardiac anatomy. These developments in the technology of clinical imaging have made it possible to reveal all the details of cardiac anatomy without distorting the relationships to the intrathoracic structures. There is no reason, therefore, why the nuances of cardiac anatomy should not now be taught to medical students using the attitudinally appropriate approach. This is more important for those who point to the advantages of virtual reality. In this review, we show how such anatomically accurate virtual reconstruction is, indeed, capable of revealing the complex three-dimensional interrelations of its component parts.

2. Ancient Contribution and theories of Anatomy of Heart:

A. Greek Contributions (Around 500 B.C.)

Establishment of the role of the heart in Ancient Greece can be traced back to the eighth century B.C, when Homer described it in his poems as the source of human courage and bravery. Following Homer were the Greek scientists who studied the heart from an anatomical perspective. Asclepios was the first Ancient Greek physician who was believed to have significant knowledge of the anatomy of the cardiovascular system. Although there are no records to demonstrate that he identified different anatomical structures, his work as a surgeon and wound-healing physician implied that he possessed insight into the anatomy of cardiac disease. Greek medicine and anatomy were split between two doctrines by the end of the fifth century. The first doctrine, in contrast to that of the ancient Egyptians, held that the brain is the center of the being, soul, mind, and consciousness. The heart was denied this function. Alcmaeon, thought to be a student of Pythagoras, adopted this belief. Alcmaeon was one of the earliest scientists to perform detailed anatomical studies. He implied that the brain is the origin of all the blood vessels supplying the body. In addition, he was the first to distinguish vaguely between arteries and veins, though with no clear anatomical explanation.

B. Hippocratic Era (Around 460 B.C.)

Scientists and physicians of the Hippocratic era adopted different approaches to understanding the human body. They based their opinions on scientific evidence and analytical thinking. Their discoveries were the source of basic anatomical knowledge about different structures in the cardiovascular system. In the Hippocratic Era, the major contributor to the study of cardiac structure was the school of Cos, the main member of which was Hippocrates. They wrote the first book detailing the anatomy of the heart and the cardiovascular system, "On The Heart." In this Hippocratic book, the heart was initially defined as a very strong muscle in an ovoid hollow, located on the left side of the human body and surrounded by lungs. The heart was pyramidal in shape and was covered by a membrane. This structure constituted the origin of vessels that transport life to the body. Hippocrates described the heart as having two ventricles connected by orifices through the inter ventricular septum. The left ventricle was described as having thicker walls and a rougher inner texture than the right. This morphological difference was attributed to the left ventricle being the site of heat generation and the pure air of life termed "pneuma" in the pre-Hippocratic era. The anatomical properties of the left ventricle allowed it to sustain the heat released. It was believed to contain only one humor, yellow bile, and membranes, but no blood. The atria or auricles were mentioned as soft hollow structures around the ventricles in close proximity to the origins of vessels. They were not recognized as part of the heart but rather as “ears” devoid of holes that served for capturing air, and as parts of the vessels connected to the heart. Each of these vessels was connected to the heart through extensions from the cardiac wall. Hippocrates recognized two types of vessel. The first transmitted air to the left ventricle and is known today as the pulmonary vein. The second transmitted air to the right ventricle and blood to the lung and is known today as the pulmonary artery. There was no mention of the aorta or venae cavae.

C. Early Posthippocratic Era (Around 384 B.C.)

In the early post-Hippocratic era, we recognize Aristotle and Praxagoras of Cos, whose work was a significant contribution to medicine and anatomy. Aristotle considered the “pneuma” to be contained in the most important organ of the body, the heart. He was another anatomist who believed in the centrality of the heart, as the origin of sensations and emotions, and as a structure that can reach and be reached by all other organs because of its location in the center. He described the heart as being mostly rounded but having an inferior pointed end that projected forward. It was located above the lungs adjacent to the tracheal bifurcation, closer to the left breast. Aristotle believed that the heart is the origin of nerves as well as both the arteries and veins. He implied that all vessels of the body except the lungs were connected to one of the two main trunks, the “great vein” and the aorta, both originating in the heart. The great vein, according to Aristotle, was the trunk that branched to form the pulmonary artery and the venae cavae. The aorta was described as a nervous vessel bearing nervous ends. He had a unique belief that the heart has three cavities. This belief became the subject of many future debates, and different explanations subsequently arose. Aristotle’s description of three cavities did not imply that he meant three ventricles as we understand ventricles today. He described three cavities, right, left, and medial, and implied that all three have pulmonary connections. The right cavity was the largest and connected to the vena cava, so he did not consider the right atrium to be part of the heart. The left cavity was smallest, and the middle cavity was connected to the great vessel or aorta. Although Aristotle did not distinguish arteries from veins anatomically, he identified the “ducts” that connected the right and the left ventricles to the lungs and functioned to provide breath to the heart. These were mostly analogous to the pulmonary artery and veins in contemporary terminology.

D. Alexandrian Era (Around 300 B.C.)

During the Alexandrian era, a better understanding of the blood vessels and heart valves was developed. Human dissection was allowed and provided better anatomical knowledge about different parts of the body . We recognize Herophilus, who rejected Aristotle’s theory of the cardiocentric nervous system origin, and Erasistratus, the first to describe heart valves precisely. Herophilus was referred to by many as “the father of anatomy”. He was one of the first to believe that the heart is made up of four chambers. He considered the atria as parts of the heart and not extensions of the vessels connected to it; Erasistratus subsequently disagreed. One of Herophilus’ major contributions to cardiovascular anatomy was to establish the characteristics of blood vessels. He was the first anatomist to distinguish precisely between arteries and veins in anatomical structure. He recognized that the arterial coat was six times thicker than the venous coat. He also noted that the vessel originating from the right ventricle and supplying the lung looked anatomically like an artery but had a vein function, and named it the "artery-like vein" or "arterial vein". This vessel is the pulmonary artery in contemporary terminology. He also noted that the vessel originating from the left ventricle had the anatomical characteristics of a vein but an artery function, and named it the "vein-like artery" or "venous artery". This vessel is the pulmonary vein in contemporary terminology. Herophilus briefly mentioned the heart valves, but it was Erasistratus who provided a detailed account of those structures. Lastly, Herophilus was the first to recognize nerve-like projections of the membranes in the mouths of the heart, which he named "sinew". It is believed that he was referring to the papillary muscles or chordae tendinae. Erasistratus was the first anatomist to define the heart as a machine or a double pump with a structure closely related to its function. In contrast to Herophilus, he believed that the heart comprised two chambers not four. The right chamber distributed blood to the body and the left distributed pneuma. He claimed that veins, just like arteries, originated in the heart not the liver, in contrast to earlier investigators. The right side of the heart was the origin of the veins while the left side was the origin of the arteries. According to Erasistratus, the arteries were "pneumatic" vessels that contained "pneuma", air, and vital spirits, but no blood; veins were the only blood containing vessels.

E. Islamic Era (Around 1000 A.D.)

Although human dissections were not permitted during the Islamic era, anatomists of that era still contributed to knowledge of the cardiovascular system, specifically through descriptions of the coronary vessels. Here we mention the contributions of Avicenna, Ibn Nafis, Al Akhawayni, Haly Abbas, and Mansur Ibn Ilyas. The contribution of Avicenna to the knowledge of cardiovascular anatomy is recorded in his treatise "The Canon of Medicine". He briefly described blood circulation and valvular function. His most notable contribution was his correct description of the pulse, when he stated that the pulse comprises two movements and two pauses. Haly Abbas provided a detailed anatomy of the heart structures based on previous discoveries. His major contribution was his description of the coronary vessels. He described the arteries branching from the aorta: one of them supplied the right ventricle and the other the left side of the heart and the left ventricles communicated. He had a fairly accurate understanding of the circulation between the heart and the lungs. He also described the heart as having four cavities, and acknowledged the atria, which he named "Kush", as parts of the heart. Al Akhawayni also provided a more detailed description of the coronary arteries. He recognized that the right branch of the aorta (right coronary artery) further divided into two branches. The left branch similarly divided further into two branches, one going to the right side while the other wrapped around the heart. We believe he was describing the left anterior descending and the circumflex arteries respectively. Mansur Ibn Ilyas was known for his anatomical illustrations of the cardiovascular system. He described two layers of the arteries: an inner layer formed of circumferential fibers and an outer layer formed of oblique and longitudinal fibers. He also described the pericardium as a cardiac sheath that protected the heart, but did not recognize the role of the lungs in blood circulation.

F. European Era (Around 1400 A.D.)

During the European era, the most impressive contribution was made by Leonardo da Vinci, who was the first to describe the four main chambers of the heart accurately as we know them today. Leonardo described the heart as a muscle nourished by arteries and veins, with a wall formed of fibers that can contract autonomously. He clearly demarcated the arteries and veins in his sketches, as seen in Figure 4. The heart was described as a four-chambered organ formed of two ventricles and two atria, with one atrium on top of each ventricle separated by orifices and sinewy membranes on each side. What was unique in his description of heart structures was the distinction between atria and auricles. He first referred to the atria as upper ventricles, to the ventricles as lower ventricles, and to the auricles as ears or auricular appendages. Like Galen, he believed in the presence of pores in the septum separating the ventricles, which allowed these chambers to communicate with each other. Da Vinci had a fairly good understanding of atrial and ventricular motion;when the atria contracted, the ventricles relaxed, and vice versa. After it was establishedthat the auricles were two distinct chambers of the heart, they were anatomically described in more detail. They were given the name “atrium”, a Latinword that refers to the main room of a Roman house. Leonardo da Vinci provided a detailed anatomical description of the aorta. Da Vinci’s sketches of the heart incorporated the aorta and the surrounding structures to show the positioning of the heart.

G. Eighteenth Century

During the eighteenth century, major anatomical structures and pathways were discovered. The patterns of pulmonary circulation were also better understood. We recognize the significant contributions of Raymond Vieussens, Adam Christian Thebesius, Jean Baptiste de Senac, and Antonio Scarpa during this era. Raymond Vieussens’ contributions were recorded in his book “Traite nouveau de la structure et des causesdu mouvement naturel du Coeur” (Treatise of the Heart). In this book, he provided a detailed description of the coronary vessels, muscle fibers, and pericardium. His descriptions were mainly aimed at establishing a relationship between anatomy and function of the heart structures. His book is characterized by a specific description of the coronary vessels and coronary sinus. He also described the collateral system of vessels, and discovered an arterial ring that provided collateral blood flow to left side of the heart in case the left anterior descending artery became occluded. This structure is now called the “Vieussens arterial ring”. He also discovered a valve located at the junction between the great cardiac vein and the coronary sinus ostium. Today, this valve is called the “Vieussens valve”. In another book called “Nouvelles d_ecouvertes sur le Coeur” (New discoveries on the Heart), Vieussens described the “ducti carnosi”, ducts joining the ventricles to the coronary arteries. Adam Christian Thebesius’ initial work is recorded in his published anatomical thesis “Disputatio medica inauguralis de circulo sanguinis in corde”. His studies in this thesis focused on a description of the venous structures of the heart, specifically the cardiac veins. He named these veins “vasa cordis minima”, and reported that they empty into heart chambers.

H. Nineteenth And Twentieth Centuries

The nineteenth and twentieth centuries were characterized by detailed anatomical studies of structures within the four chambers of the heart, and the discovery of the conducting system. The conducting system was discovered by His and Purkinje, and completed by contributions from Tawara. In 1839, Purkinje described a bundle of fibers connecting the atria and ventricles, now called Purkinje fibers. In 1893, His described a bundle of fibers located in the myocardium, now called the bundle of His. In 1904, Retzer and Braeunig observed the branches of the bundle. He discovered the atrio-ventricular node, and also related the anatomy to the function of different structures of the conducting system. He established the role of the Purkinje fibers as part of the AV conducting system. Robert Anderson revolutionized the way anatomists view conductive tissue. He was introduced to the congenital malformations of the heart when he observed a surgeon placing a stitch to surround the conduction bundle between the atria and ventricles. Anderson revisited areas of the conductive tissue that had previously been described by German pathologists but had subsequently been marginalized. Anderson has published work on most of the congenital cardiac malformations. Amongst his most notable work was his clarification of the morphological changes that occur during congenital malformations within the heart and the location of the conductive system.

3. History of pulmonary circulation at a glance

The table below summarizes the physicians throughout history who contributed to our understanding of the pulmonary circulation. It really starts with Hippocrates and ends with Marcello Malpighi…

Hippocrates (Buqrat)	460-377 BC
Aristotle (Arastu)	384-322 BC
Erasistratus (Aerasistratoos)	290 BC
Galen (Jalinus)	129-200 BC
Annafis (Ibne Nafis)	1210-1288 AD
M. Servetus	1511-1553 AD
Andreas Vesalius	1514-1564 AD
Realdus Columbus	1516-1559 AD
Caesalpinus	1519-1603 AD
Fabricius de Aquapendente	1537-1619 AD
William Harvey	1578-1657 AD
Marcelo Malpighi	1628-1698 AD

4. Postulates of various ancient physicians about the circulation:

A. Hippocrates (Buqrat; 460-377 BC):

Hippocrates, the Father of Medicine, believed that the liver and the spleen were the central organs within which blood travelled to the heart to be warmed or cooled by the air entering the lungs and the heart via the trachea.

B. Aristotle (Arastu, 384-322 BC):

Attributed three ventricular chambers to the heart; he named the main artery of the heart as Aorta.

C. Erasistratus (330/304/290 BC):

Arteries contain air. He said air from the lungs goes to the heart and changes into vital spirit. He gave the names of vessels, like artery, vein, pulmonary artery and pulmonary vein, etc.

Concept of reverse circulation: "The blood which oozes out through artery when cut comes from veins through very small vessels between artery and vein".

D. Galen (Jalinus, 129-200 AD):

In his book "De Usu Partium" Galen wrote: Arteries carried blood instead of air. Veins as well as arteries both carry blood towards the extremities. According to Galen, there were two kinds of blood: Spiritual blood (arterial blood, present in left heart); venous blood (present in right heart). Spiritual blood nourishes light and delicate texture organs e.g. lungs, and venous blood nourishes those of heavy and gross texture organs e.g. liver. About arteries he said that they have the property to pulsate i.e. pulsative faculty or pulsific virtue. There are certain openings in the interventricular septum through which some amount of blood goes from right side to left side of the heart. Galen placed the seat of sanguification in the liver. [Sanguification = conversion of blood = hematopoiesis - Ed.] Galen believed that blood was propelled inside the vessels by attraction from peripheral tissues in need of nutrition (he did not recognized the pumping action of the heart). Galen believed that blood perfuse into the organs like water in irrigating fields.

Galen could not explain how blood produced in the liver and carried to the right heart by vena cava reached the left heart so that it could be distributed to the arterial tree. Galen had a good notion of the aortic, pulmonary and cardiac valves and said that arteries and veins communicate by common openings which are invisible and extremely narrow.

E. Ibn Nafis (1210-1288 AD):

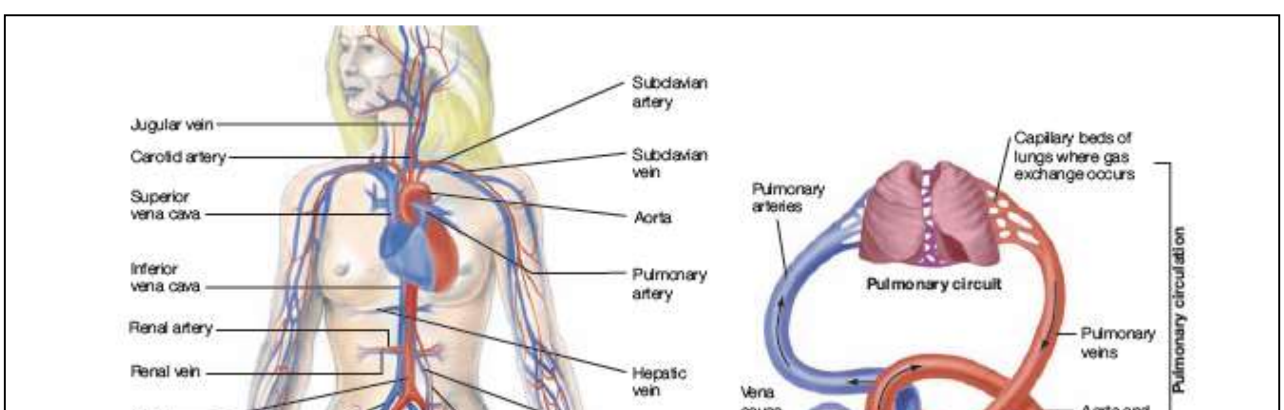
Ala ad-Din Abu al-Hasan Ali Ibn Abi-Hazm-al-Qarshi known as Ibn Nafis Damishqi, was born in a small town near Damascus called Qarsh. He is considered as the **Father of Circulatory** Physiology. In 1236 AD he moved to Egypt, worked in Almansouri Hospital and became the chief of physicians and the Sultan's personal physician there. He wrote many books in medicine but his most famous book was Sharah al Tashreeh al Qanoon (Commentary on anatomy of the Canon of Avicenna)**.** This book was forgotten until 1924 when an Egyptian physician, Dr M. Altatawi discovered manuscript No.62243 titled "Commentary on the anatomy of the Canon of Avicenna" in the Prussian state Library in Berlin, Germany. This book contains the first description of the pulmonary circulation.

5. Anatomy of Human heart and Location:

The heart weighs around 350g and is roughly the size of an adult's clenched fist. It is enclosed in the mediastinal cavity of the thorax between the lungs, and extends downwards on the left between the second and fifth intercostal space. If one draws an imaginary line from the middle of the left clavicle down to below the nipple, this is where the most forceful part of the heart, the apex beat, can be felt. The heart has a middle muscular layer, the myocardium, made up of cardiac muscle cells, and an inner lining called the endocardium. The inside of the heart (heart cavity) is divided into four chambers – two atria and two ventricles – separated by cardiac valves that regulate the passage of blood. The heart is enclosed in a sac, the pericardium, which protects it and prevents it from over-expanding, anchoring it inside the thorax. The pericardium is attached to the diaphragm and inner surface of the sternum, and is made up of:

A. The fibrous pericardium, composed of a loosely fitting but dense layer of connective tissue;
B. The serous pericardium or epicardium, composed of the parietal and visceral layers;
C. A film of serous fluid between the fibrous and serous pericardium that allows them to glide smoothly against each other.

One of the first rules of human anatomy is that all bodily parts should be described as viewed in the so-called anatomical position. This means that the heart should be described as it is normally positioned within the thorax. It is difficult in the dissecting room, however, to assess the interrelationships of the cardiac components while the organ itself remains embedded within the mediastinum and encased by the thoracic skeleton and the lungs. It is almost certainly the need to remove the heart from the thorax so as



The circulatory system of heart in human body

to identify its individual components that has led to its usual description in so-called “Valentine” fashion. In this arrangement, which is currently followed in the greater majority of textbooks used for education of medical students, the organ is shown as positioned on its apex. In the Valentine approach, the atrial chambers are shown inappropriately directly above the ventricles, with the right-sided structures shown as though truly right-sided relative to their allegedly left-sided counterparts. When taking advantage of the images obtained from datasets prepared using the commercially available software used by clinicians, it is now possible to show the heart as it is properly situated within the thorax

6. Atria and ventricles

The atria receive blood returning to the heart, while the ventricles receive blood from the atria – via the atrioventricular valves – and pumps it into the lungs and the rest of the body. The left atrium (LA) and left ventricle (LV) are separated from the right atria (RA) and right ventricle (RV) by a band of tissue called the septum. The RA receives deoxygenated blood from the head and neck and from the rest of the body via the superior and inferior vena cava, respectively. The RV then pumps blood into the lungs (through the pulmonary trunk, which divides into the right and left pulmonary arteries), where it is oxygenated. The oxygenated blood is returned to the LA via the pulmonary veins and passes into the LV through the cardiac valves. From the LV, it is delivered to the whole body through the aorta. The RV does not need a huge amount of force to pump blood into the lungs, compared with the LV, which has to pump blood into the rest of the body. The LV has a thicker wall and its cavity is circular, while the RV cavity is crescent-shaped with a thinner wall.

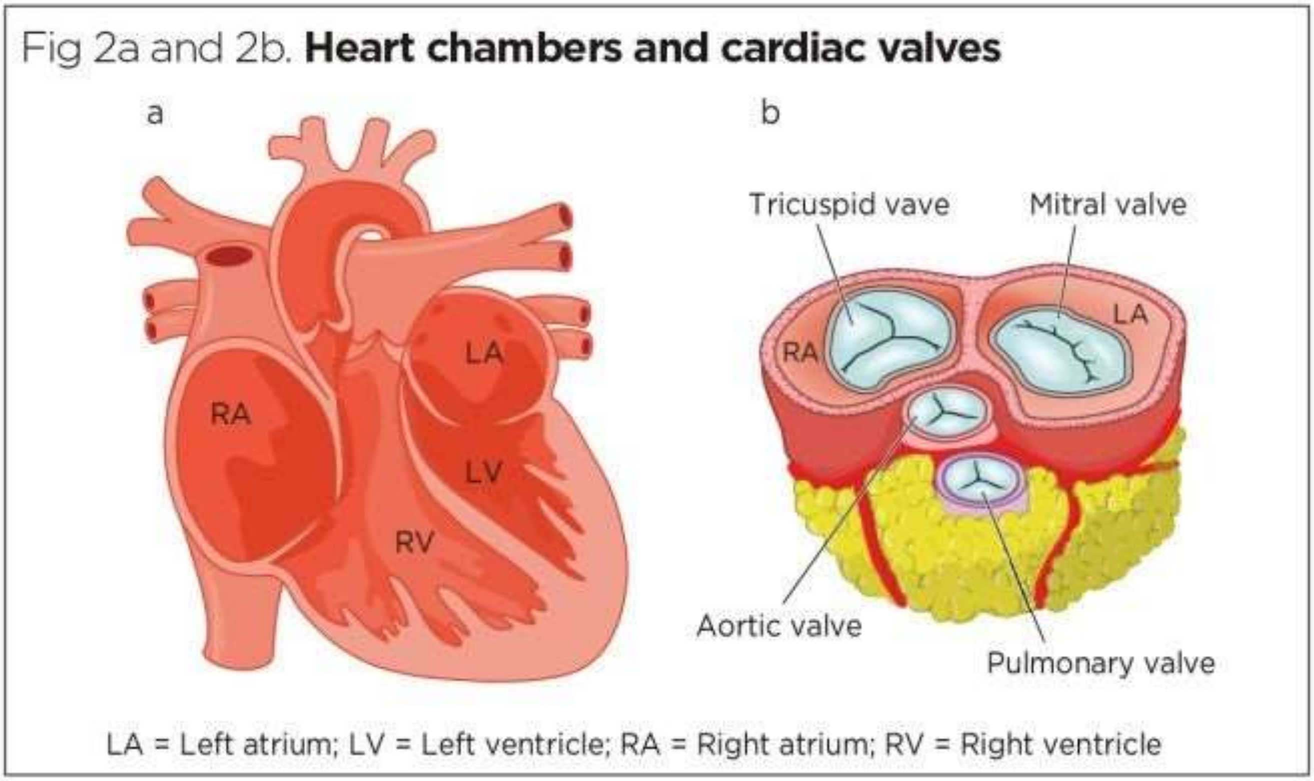


Fig 2a and 2b. **Heart chambers and cardiac valves**

LA = Left atrium; LV = Left ventricle; RA = Right atrium; RV = Right ventricle

The heart consists of four chambers:

- **A. The atria:** These are the two upper chambers, which receive blood.
- **B. The ventricles:** These are the two lower chambers, which discharge blood.

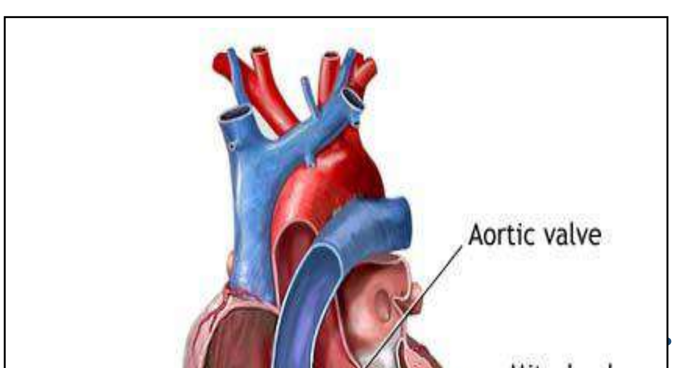
A wall of tissue called the septum separates the left and right atria and the left and right ventricle. Valves separate the atria from the ventricles.

The heart's walls consist of three layers of tissue:

- A. **Myocardium:** This is the muscular tissue of the heart.
- B. **Endocardium:** This tissue lines the inside of the heart and protects the valves and chambers.
- C. **Pericardium:** This is a thin protective coating that surrounds the other parts.
- D. **Epicardium:** This protective layer consists mostly of connective tissue and forms the innermost layer of the pericardium.

7. Cardiac valves

When working correctly, the cardiac valves ensure a one-way system of blood flow. They have projections (cusps) held in place by strong tendons (chordae tendinae) attached to the inner



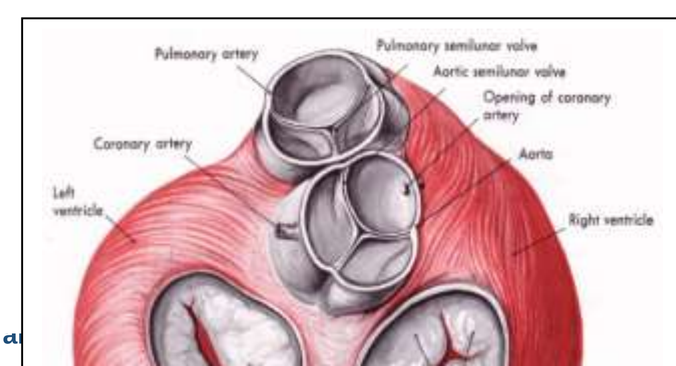


Fig. Cardiac valves longitudinal section	Fig. Cardiac valve Transverse section

walls of the heart by small papillary muscles. The RA and RV are separated by the tricuspid valve, which has three leaflets. The tricuspid valve allows deoxygenated blood to move from the RA into the RV. From the RV, blood passes through the pulmonary valve (situated between the RV and the pulmonary artery), allowing deoxygenated blood to enter the lungs. On the left side of the heart, oxygenated blood from the lungs enters the LA from the pulmonary vein. The LA is separated from the LV by the mitral valve and blood flows through this valve into the LV. It then passes through the aortic valve into the aorta, which transports oxygenated blood throughout the body. The heart has four valves to ensure that blood only flows in one direction:

A. **Aortic valve:** This is between the left ventricle and the aorta.
B. **Mitral valve:** This is between the left atrium and the left ventricle.
C. **Pulmonary valve:** This is between the right ventricle and the pulmonary artery.
D. **Tricuspid valve:** This is between the right atrium and right ventricle.

Most people are familiar with the sound of the heart. In fact, the heart makes many types of sound, and doctors can distinguish these to monitor the health of the heart. The opening and closing of the valves are key contributors to the sound of the heartbeat. If there is leaking or a blockage of the heart valves, it can create sounds called "murmurs."

8. Diastole, systole, and blood pressure

Each heartbeat has two parts:

A. Diastole: The ventricles relax and fill with blood as the atria contract, emptying all blood into the ventricles.

B. Systole: The ventricles contract and pump blood out of the heart as the atria relax, filling with blood again.

When a person takes their blood pressure, the machine will give a high and a low number. The high number is the systolic blood pressure, and the lower number is the diastolic blood pressure.

Systolic pressure: This shows how much pressure the blood creates against the artery walls during systole.

Diastolic pressure: This shows how much pressure is in the arteries during diastole.

9. Gas exchange

When blood travels through the pulmonary artery to the lungs, it passes through tiny capillaries that connect on the surface of the lung's air sacs, called the alveoli. The body's cells need oxygen to function, and they produce carbon dioxide as a waste product. The heart enables the body to eliminate the unwanted carbon dioxide. Oxygen enters the blood and carbon dioxide leaves it through the capillaries of the alveoli. The coronary arteries on the surface of the heart supply oxygenated blood to the heart muscle.

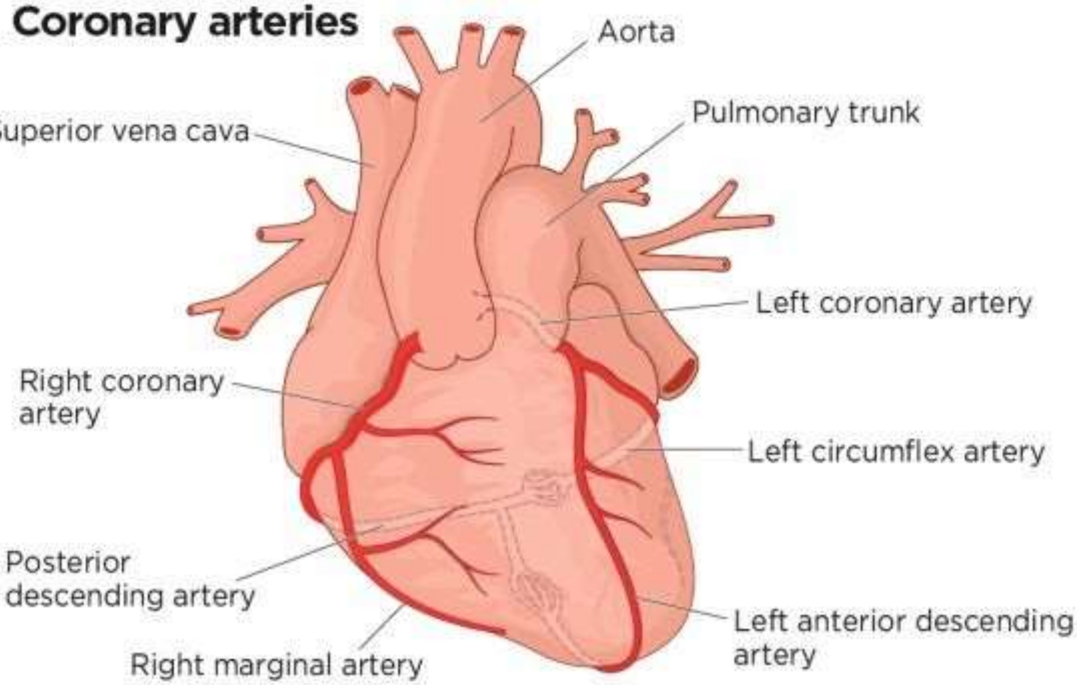
10.Pulse

A person can feel their pulse at points where arteries pass close to the skin's surface, such as on the wrist or neck. The pulse is the same as the heart rate. When you feel your pulse, you feel the rush of blood as the heart pumps it through the body. A healthy pulse is usually 60–100 bpm, and what is normal can vary from person to person. A very active person may have a pulse as low as 40 bpm. People with a larger body size tend to have a faster pulse, but it is not usually over 100 bpm.

11.Coronary circulation

The heart itself requires a richly oxygenated blood supply to support its activity. This is delivered via the right and left coronary arteries, which lie on the epicardium and penetrate the myocardium with deeper branches to supply this highly active layer of muscle. The right and left coronary arteries arise from vascular openings at the base of the aorta, called the coronary ostia. The left coronary artery runs towards the left side of the heart, dividing into the left anterior descending artery and the left circumflex artery. The right coronary artery runs down the right side of the heart dividing into the marginal artery (lateral part of the right-hand side of the heart) and posterior descending artery (supplying the posterior part of the heart).

Fig 3. **Coronary arteries**



The coronary arteries provide an intermittent supply of blood to the heart, predominantly when the heart is relaxed (during diastole), as the entrance to the coronary arteries is open at that point of the cardiac cycle. Table 1 shows which regions of the heart are supplied by which coronary arteries.

Table 1. Coronary arteries and regional blood supply to the heart

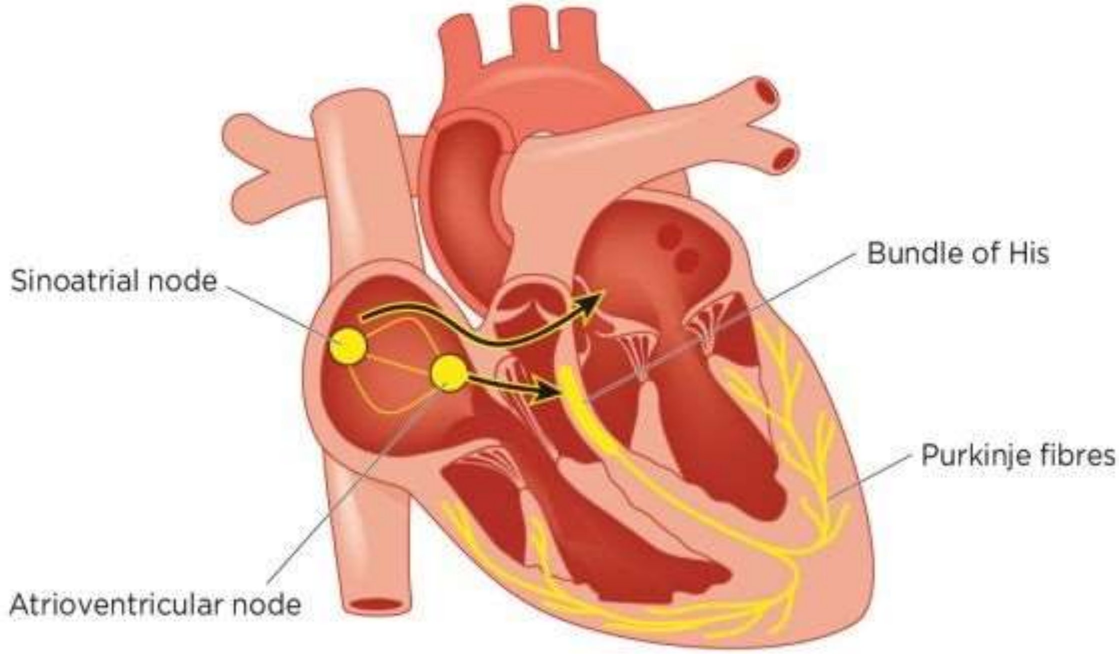
Coronary artery	Anatomical region of the heart supplied by it
Right coronary artery	Inferior aspect
Left anterior descending artery	Anteroseptal and anteroapical aspects
Left circumflex artery	Anterolateral aspect

The venous drainage system of the heart uses the coronary veins, which follow a course similar to that of the coronary arteries. The coronary sinus is a collection of coronary veins (small, middle, great and oblique veins, left marginal vein and left posterior ventricular vein) that drain into the RA at the posterior aspect of the heart. Two thirds of the cardiac venous blood is returned to the heart via the coronary sinus, while one third is returned directly into the heart (with the anterior cardiac veins opening directly into the RA and the smallest coronary veins into all four chambers).

12.The conduction system and heart rhythm

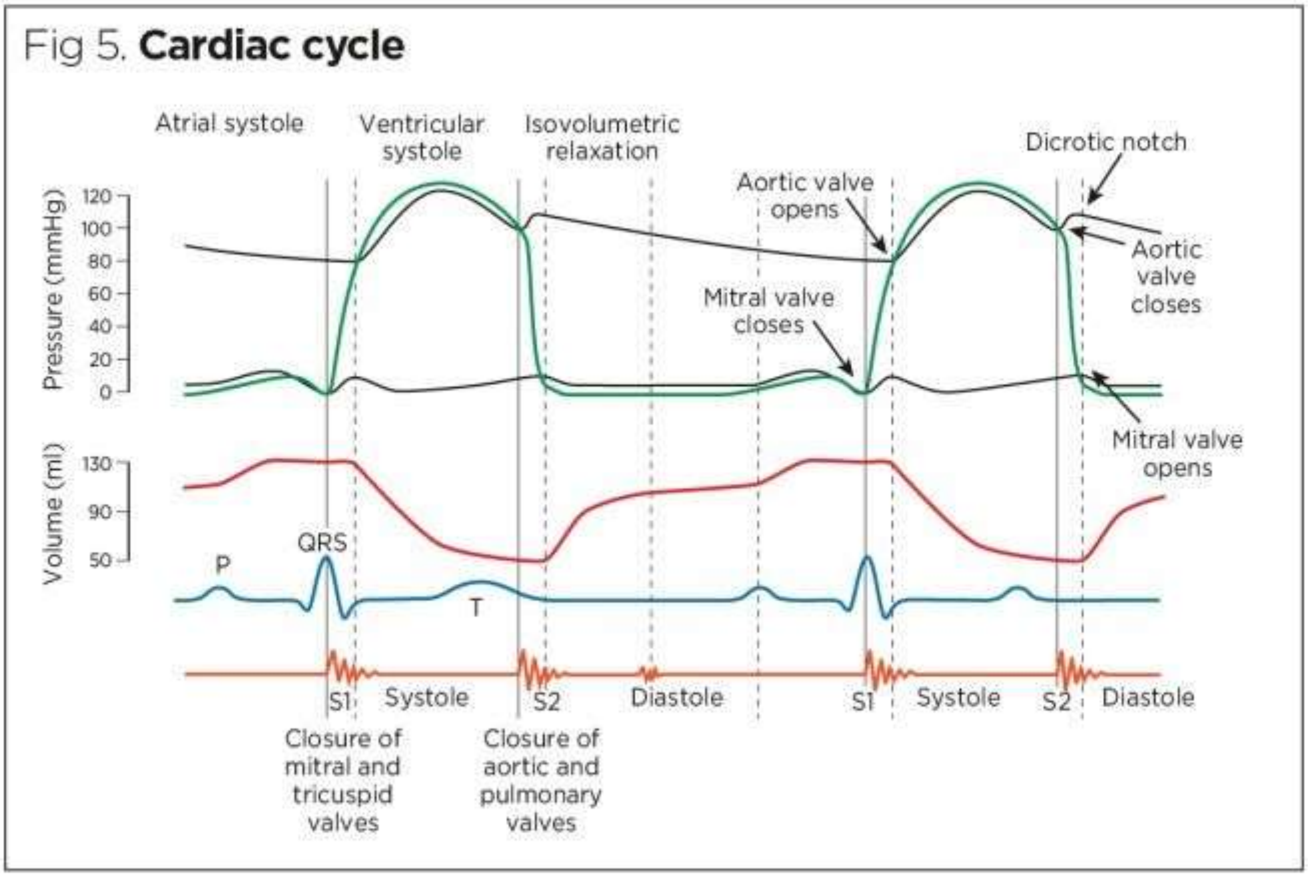
The cardiac muscle has the ability to undergo depolarisation (change in the excitation of a cell), which leads to a contraction of the muscle cells. In the heart, the electrical changes needed to generate a cardiac impulse are regulated by its own conduction system, which starts with a sequence of excitation in a specialised area of cardiac cells, the sinoatrial node (SAN), situated in the right atrium. This is the heart's natural pacemaker. When working properly, it sets the heart rhythm (sinus rhythm) and initiates impulses that act on the myocardium, stimulating cardiac contraction. The cardiac impulse passes from the SAN into the atria, which starts to contract, and the impulse is transmitted to another mass of specialised cells, the atrioventricular node (AVN). The AVN is situated in the inter-atrial septum, a band of tissue between the RA and LA that provides a pathway of conduction between the atria and the ventricles. There is a slight delay (of 0.1 seconds) of the impulse at the AVN because the fibres of the AVN are smaller, which gives the atria time to contract and empty into the ventricles before ventricular contraction occurs. The impulse then travels down into a large bundle of specialised tissue, the Bundle of His, which conducts it down the ventricles. The Bundle of His subsequently splits into the right and left bundles in the interventricular septum. Purkinje fibres then continue down to the inferior aspect of the heart, before looping upwards and travelling in the lateral aspects of the RV and LV.

Fig 4. **Conduction system of the heart**



13.Cardiac cycle

The chambers of the heart contract and relax in a coordinated fashion. The contraction phase is referred to as ‘systole’ and the relaxation phase, when the heart fills up again, as ‘diastole’. The RA and LA synchronise during atrial systole and diastole, while the RV and LV synchronise during ventricular systole and diastole. One complete cycle of these events is referred to as the cardiac cycle. During the cardiac cycle, the pressure in the cardiac chambers increases or falls, affecting valve opening or closure, thereby regulating blood flow between the chambers. Pressures in the left side of the heart are around five times higher than in the right side, but the same volume of blood is pumped per cardiac beat. The cardiac cycle can be broken down into a sequence of events based on the principle that any blood flow through the chambers depends on pressure changes, as blood will always flow from a high-pressure to a low-pressure area (Marieb and Hoehn, 2015). The process is shown in Fig. and described below.



14.Atrial systole and ventricular filling

At this part of the cardiac cycle, the pressure in the heart is low and the blood from the circulation passively fills the atria on both sides. This culminates in the opening of the atrioventricular valves and blood moving into the ventricles. Around 70% of ventricular filling occurs during this phase. After de-polarisation of the atria (P wave on an electrocardiogram [ECG]),the atria contract compressing blood in the atrial chambers and push residual blood out into the ventricles.

This signifies the last part of the ventricular resting phase (diastole) and the blood within the ventricles is referred to as the end diastolic volume (EDV). The atria then relax and then the electrical impulse is transmitted to the ventricles, which undergo de-polarisation (QRS wave on an ECG).

A. Ventricular systole

At this point, the atria are relaxed and the ventricles begin to contract. This contraction of the ventricles leads to an increase in ventricular pressures within the cavity. As the pressure rises, it exceeds the pressure within the arteries, forcing the opening of the aortic and pulmonary valves as blood is ejected from ventricles and into these large vessels.

B. Iso-volumetric relaxation

At this point, the ventricles relax and any blood remaining in the chamber is called end systolic volume (ESV). The ventricular pressure precipitously drops and as this occurs, blood within the aorta and pulmonary trunk momentarily backflow and the aortic and pulmonary valves close. This backflow causes a brief rise in the pressure in the aorta giving a characteristic change in the pressure of the cardiac cycle called the dicrotic notch. While the ventricles have been in systole, the atria are in diastole and fill again ready for the next cardiac cycle.

15. Cardiac output and stroke volume

Cardiac output (CO) is the amount of blood pumped out by the heart in one minute. CO can be calculated using a simple equation: the stroke volume (SV) – the volume of blood pumped by the ventricles with each heart beat – multiplied by the heart rate.

First, one needs to calculate the SV – the difference between the EDV (the volume of blood left in the ventricles during diastole) and the ESV (the volume of blood remaining in the ventricles after it has contracted). If the EDV is 120ml and the ESV is 50ml, the SV will be:

- 120ml (EDV) - 50ml (ESV) = 70 ml/beat (SV)

Once the SV has been determined, the CO can be calculated. If the SV is 70mls and the heart rate is 70bpm, the CO will be:

- 70ml (SV) x 70bpm (heart rate) = 4,900ml/min (CO)

The CO can vary; for example, it will increase in response to metabolic demands such as exercise or pregnancy. In pathological states such as heart failure, the CO may not be sufficient to support simple activities of daily living or to increase in response to demands such as mild-to-moderate exercise.

16. Conditions and Disorders

Heart conditions are among the most common types of disorders affecting people. In the United States, heart disease is the leading cause of death for people of all genders and most ethnic and racial groups. Common conditions that affect your heart include:

A. **Atrial fibrillation (Afib):** Irregular electrical impulses in your atrium.
B. **Arrhythmia:** A heartbeat that is too fast, too slow or beats with an irregular rhythm.
C. **Cardiomyopathy:** Unusual thickening, enlargement or stiffening of your heart muscle.
D. **Congestive heart failure:** When your heart is too stiff or too weak to properly pump blood throughout your body.
E. **Coronary artery disease:** Plaque buildup that leads to narrow coronary arteries.
F. **Heart attack (myocardial infarction):** A sudden coronary artery blockage that cuts off oxygen to part of your heart muscle.
G. **Pericarditis:** Inflammation in your heart’s lining (pericardium).

17. Care for heart healthy.

If you have a condition that affects your heart, follow your healthcare provider’s treatment plan. It’s important to take medications as prescribed.

You can also make lifestyle changes to keep your heart healthy. You may:

- Achieve and maintain a healthy weight for your sex and age.
- Avoid Drink alcohol.

- Eat a heart-healthy diet with plenty of fruits, vegetables and whole grains.
- Exercise moderately for at least 150 minutes per week.
- Limit your sodium intake.
- Manage your stress with healthy strategies like meditation or journaling.
- Quit smoking and/or using tobacco products and avoid secondhand smoke.

Conclusion

The heart is an essential, powerful organ that constantly pumps oxygen and nutrients around the body. If a person is born with congenital heart disease, or if damage occurs due to illness or other factors, the heart's function may diminish, and this can lead to life threatening complications, such as heart failure. If the heart stops, a person cannot survive for long. Staying active and maintaining a healthful diet are two ways to protect the heart.

In conclusion, reviewing the history of cardiovascular system anatomy, we realize that each era contributed significantly to today's knowledge of the anatomy of the heart. Even though the pre-Hippocratic era provided a more religious and holistic understanding of cardiac anatomy, ancient Egyptians and Greeks still recognized the presence of blood vessels and acknowledged the role of the heart in transporting materials to other parts of the body. During subsequent eras, anatomists tried to

understand the true function of the heart and relate it to structure. Even though he made this mistake, Galen's description of different components of the heart demonstrates that he had a fairly simple but accurate understanding of the work of the heart. Subsequent studies were built on these initial explanations of heart structures, until anatomists and physicians were able to relate the nature of different cardiovascular illnesses to the malfunctioning of different anatomical structures.

References:

1. Cardiovascular Consultants 2006, Heart Anatomy, viewed December 2010, www.cardioconsult.com/Anatomy
2. Cleveland Clinic 2009, Your Heart and Blood Vessel, viewed May 2011, www.my.clevelandclinic.org /heart/disorders/cad/cad_arteries.aspx
3. Hatchett, R. & Thompson, D. (ed) 2007, Cardiac Nursing: A Comprehensive Guide, 2nd edn, Churchill Livingstone Elsevier, London.
4. Woods, S, Froelicher, E, Motzer, S & Bridges, E 2005, Cardiac Nursing, 5th edn, Lippincott Williams & Wilkins, Philadelphia.
5. Kenny, WL,Wilmore, JH, Costill, DL. Cardiovascular System and its Control. In Physiology of Sport and Exercise, 5rdedn. Human Kinetics, 2011. 140-150.
6. Inovqheart Heart Available from: https:// www.inovaheart.org/upload/docs
7. Radiopedia Heart Available: https://radiopaedia.org/articles/heart?lang=gb (accessed 17.6.2021)
8. Manishaben Jaiswal, "DATA MINING TECHNIQUES AND KNOWLEDGE DISCOVERY DATABASE", IJRAR - International Journal of Research and Analytical Reviews (IJRAR), E-ISSN

2348-1269, P- ISSN 2349-5138, Volume.2, Issue 1, Page No pp.248-259, February 2015, Available at : http://www.ijrar.org/IJRAR19D2907.pdf

9. Malouf, JF, Edwards, WD, Tajil, AJ, Seward, JB. Functional anatomy of the heart. In: Fuster, F, Alexander, RW, O'Rourke, RA editors. Hurst's: The Heart. 10th edn. McGraw-Hill Inc., 2001. p19–62.
10. Drake, RL, Vogl, W, Mitchell, AW, Gray, H. Gray's anatomy for Students 2nd ed. Philadelphia : Churchill Livingstone/Elsevier, 2010.
11. Rehman I, Rehman A. Anatomy, Thorax, Heart. [Updated 2020 Dec 28]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 Jan Available:https://www.ncbi.nlm.nih.gov/books/NBK470256/ (accessed 17.6.2021)
12. Moore, KL, Dalley, AF. Clinically oriented anatomy. 6th ed. Philadelphia: Lippincott Williams & Wilkins. 2009
13. Gittenberger-de Groot AC, Bartelings MM, Deruiter MC, Poelmann RE. Basics of cardiac development for the understanding of congenital heart malformations. Pediatr Res 2005;57:169-176.
14. Wessels A, Sedmera D. Developmental anatomy of the heart: a tale of mice and man. Physiol Genomics 2003;5:165-176.
15. Linder J, Shelburne JD, Sorge JP, Whalen RE, Hackel DB. Congenital endodermal heterotopia of the atrioventricular node: evidence for the endodermal origin of so-called mesotheliomas of the atrioventricular node. Hum Pathol 1984;15:1093-1098.
16. Ariza S, Rafel E, Castillo JA, Garcia-Canton JA. Intracardiac heterotopia—mesenchymal and endodermal. Br Heart J 1978;40:325-327.
17. Orlandi A, Ciucci A, Ferlosio A, Genta R, Spagnoli LG, Gabbiani G. Cardiac myxoma cells exhibit embryonic endocardial stem cell features. J Pathol 2006;209:231-239.
18. Aird WC. 2011. Discovery of the cardiovascular system: From Galen to William Harvey. J Thromb Haemost 9:118–129. Galen. 2004. Galen's collected writings. Use of Parts, Vol. 12. Athens:Kaktos.
19. Ghiselin MT. 1966. William Harvey's methodology in De motu cordis from the standpoint of comparative anatomy. Bull Hist Med 40: 314–327.
20. Hajar R. 1999. "The Greco-Islamic Pulse". Heart Views 1:136–140.
21. Harris CRS. 1993. The Heart and the Vascular System in Ancient Greek Medicine. Oxford: Oxford University Press. p 1–28.
22. Hart GD. 1965. Asclepius, God of medicine. Can Med Assoc J 92:232–236.