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MODERN ANALYSIS OF THE MORPHOFUNCTIONAL STATE AND INFLUENCE OF INTERNAL AND EXTERNAL FACTORS ON THE AORTIC VESSELS

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Introduction.

In recent decades, the development of society and the acceleration of technological processes have led to an increase in stress factors affecting the human body. Chronic stress is a disease that affects millions of people worldwide and is associated with many health problems such as cardiovascular disease, hypertension, and mental health disorders. A specific cardiovascular disease that can be caused by chronic stress is stenosis of the aorta and stenosis of the pulmonary trunk. Aortic stenosis is a progressive disease characterised by a narrowing of the aortic valve, designed to regulate blood flow from the heart to the rest of the body. (https://medshun.com/article/canstress-make-aortic-stenosis-worse.)

Stress is the body's defense-response reaction to external or internal environmental factors, and short-term stress can sometimes trigger beneficial adaptation mechanisms. However, chronic and prolonged stress leads to disruption of physiological processes, profound changes in the endocrine, nervous, cardiovascular, and immune systems. Especially in pregnant women, stressful processes affect not only the health of the mother, but also the nervous system of the developing fetus and the vascular system. This leads to the development of various pathological conditions in the offspring.

Anatomy of aortic vessel

The aorta is a unique single and largest blood vessel in the human body. It starts from the left ventricle of the heart and is the beginning of the systemic circulation that delivers oxygen and nutrients to the organs and tissues of the body. The aorta is an elastic vessel. This means that its wall contains a large number of elastic fibers, which allows the aorta to be elastic and resistant. During systole (the period of heart muscle contraction), blood is displaced from the ventricles at a speed from 0.5 m/s to 1.3 m/s and under pressure equal to 120-130 millimeters of mercury. Due to its structure, the walls of the aorta stretch under blood pressure and then return to their original state. (Aneurysm of the thoracic aorta. Symptoms, diagnosis and treatment of pathology:: Polismed.com).

Morphology of the development of the aortic vessel in mammals

The aorta is the largest elastic artery in the human body and is traditionally divided into two anatomical segments called the thoracic and abdominal aorta, separated by the diaphragm. The thoracic aorta: includes the bulbar aorta, ascending aorta, aortic trunk, and descending aorta. The elastic properties of the aorta depend on the structure of the wall, which consists of three separate histological layers called the intima, media, and adventitia. Different segments of the aorta have different embryological and anatomical features, which affects their physiological characteristics and influences the occurrence and natural course of congenital and acquired diseases developing here. Diseases of the thoracic aorta can manifest as chronic, often asymptomatic disorder or acute life-threatening conditions, i.e., acute aortic syndromes, and are usually associated with conditions that increase the load on the wall and alter the structure of the aortic wall.

In mammals, the main blood vessels, taking blood from the heart and delivering it to the lower part of the body and head, originate from the aortic arch. Initially symmetrical, these arteries are formed sequentially from the mesenchyme in the main or inferior direction. The development of the aortic root is closely related to the development of the cardiac outlet (Fig. 1). In the middle of the 5th week of embryogenesis, the cells of the neutral edge migrate to the trunculus arteriosus, forming a spiral conotrunkal septum, which separates the exit ducts of the aorta and pulmonary trunk. From the walls of each duct, the lamellae of the semilunar valves of the aorta and pulmonary artery are formed from three endocardial edema.

Deepening of the trunk tissue below the aortic edema leads to the formation of the Valsalva sinus. (MDPI and ACS Styledi Gioia, C.R.T.; Ascione, A.; Carletti, R.; Giordano, C. Thoracic Aorta: Anatomy and Pathology. *Diagnostics* 2023, *13*, 2166. https://doi.org/10.3390/diagnostics13132166)

In the third week of pregnancy, the isolated vascular islands merge to form a paired aorta. Each aorta consists of a continuous ventral and dorsal segment in the first aortic arch. The two ventral aorta truncus arteriosus are connected to the main vessel. The dorsal aorta extends along the entire length of the embryo, joining at 4 weeks from the fourth thoracic segment to the fourth lumbar segment, forming the middle dorsal aorta. It subsequently becomes the descending aorta. By the 5th week, the 2nd, 3rd, 4th, and 6th aortic arches develop from the aortic fossa and connect to the dorsal aorta. With the formation of subsequent arches, the first and second arches undergo regression. The common carotid artery and the proximal portions of the internal carotid artery originate from the third pair of the aortic arch. The distal part of the internal carotid arteries originates from the head of the dorsal aorta. The development of the fourth arches is asymmetrical. On the right, the fourth arch forms the proximal part of the right subclavian artery. The distal part of the right subclavian artery originates from the right dorsal aorta. The aortic arch forms the brachiocephalic trunk and the first part of the aortic arch. On the left, the fourth arch transforms into the aortic arch.

Figure 2. Details. (Viewed in three dimensions prepared for mouse and human development: mouse (A) and human (B) based on embryo and fetal data sets, showing rapid growth on the anterior-posterior axis and changes in the location of the developing heart relative to the seventh cervical segment. (Front. Cell Dev. Biol.,

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Figure -2

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The sixth arch forms the main pulmonary artery, its branches, and the arteriosus canal. Here, from the cells of the neutral edge, the aorta and pulmonary trunk play an important role in the formation of the pulmonary septum, which fuses with the collateral wall, separating the aortic and pulmonary canals. On the left, the distal part of the left arch remains in connection with the dorsal aorta and forms the arterial duct (ductus arteriosus). The arterial duct is closed at birth and later transforms into the ligamentum arteriosum, which provides the connection between the pulmonary trunk and the aorta. (*MDPI and ACS Styledi Gioia, C.R.T.; Ascione, A.; Carletti, R.; Giordano, C. Thoracic Aorta: Anatomy and Pathology. Diagnostics 2023, 13, 2166. https://doi.org/10.3390/diagnostics13132166).*

Figure 3. Details. (Development of the aortic arch arteries in human and mouse embryos. Three-dimensional reconstructions of the aortic arch arteries of mouse (A-G) and human (H-N) embryos in the developmental sequence were prepared from HREM datasets. For cats, the embryonic (E) and theiler stage (TS) are indicated, while for humans, the Carnegie stage (CS) and post-pregnancy days (dpc) are indicated. (A-G) In the cat at stage E9.0, a paired ventral aorta (also called the first arch arteries) and second arch arteries were formed (A). The arteries of the third arch are formed at the somitic (c) stage (B), and the arteries of the fourth arch are formed at the 31st stage (C). At this stage, the first and second arch arteries are interrupted. (D) By the end of E10.5, the third, fourth, and final (*) arc arteries are symmetrical and equal in size, while the proximal part of the second arc arteries is preserved. (E) In E11.5, the arch arteries begin to reform, accompanied by septation of the excretory duct (cyanoid axis), thinning of the right terminal arch artery (cyanoid axis), and carotid canal (yellow axis). The aortic sac develops branches

(pink arches) that direct blood from the aorta to the arteries of the third and fourth arches. (F) By E12.5, the arch arteries are reshaped, the right dorsal aorta is thinned, and the primitive subclavian complex "moves" forward relative to the position of the heart.)

The structure of the aortic wall consists of:

Inner layer (tunica intima). The intima is approximately 130 micrometers thick and consists of a single continuous layer of endothelial cells. The inner and middle layers are connected by a layer of connective tissue called subendothelium. The inner layer has a very thin and delicate structure. It performs barrier, immune, and vasomotor (narrowing or dilating the vascular channel) functions. It also participates in the regulation of blood clotting components (fibrin and thrombin) **.** Medium layer (tunica media). The middle layer is the strongest layer of the vessel, ensuring the stability of the aortic wall at high blood pressure. Its thickness in the ascending aorta

Figure -3

(aorta ascendens) is 1.2 millimeters, and the total thickness of the aortic wall is 2 millimeters. Collagen and elastin fibers are the main components of the middle layer, each constituting 20-30% of the total mass. Smooth muscle cells are the source of all components of this layer, constituting 5% of the total mass. In the ascending part, these cells are located in a curved position, increasing the strength of the wall, and then transition to a circular (cylindrical) position, performing the function of cylindrical muscles. External layer (tunica externa). The outer layer (adventitia) consists of loose connective tissue. It contains collagen and elastin fibers, fibroblasts (main connective tissue cells that synthesize intercellular tissue structures), and macrophages (cells that capture and digest antigenic substances). Nerve fibers (nerv vasorum) and small vessels (vasa vasorum) pass through the adventitia. Nutrients pass through the adventitia and the outer third of the middle layer (tunica media) via a network of small vessels called vasa vasorum. Delamination occurs precisely in this part of the wall. Through the lumen of the intima and part of the middle wall of the aorta, nutrients pass through diffusion.

The ascending aorta originates from the left ventricle of the heart and continues to the brachiocephalic trunk (truncus brachiocephalicus), where it passes into the aortic arch. Its total length is about 4-8 centimeters, and the diameter in the middle part is 1.5-3 centimeters. This section is called the cardio-aorta. At the head of the ascending aorta, there is a small dilation with a diameter of 25-30 millimeters, which is called the bulbus aortae (bulbus aortae). The bulbus has three small appendages, called the aortic sinuses (sinus aortae) or Valsalva sinuses. The semilunar valves (valvulae semilunares) originate from the edge of the sinuses and form the aortic valve (valva aortae). The aortic valve opens during systole (the period of heart muscle contraction). This allows blood to flow from the heart into the systemic circulation. During diastole (the period of heart muscle relaxation), the valve closes, preventing the reverse flow of blood.

The right and left coronary arteries (aa. coronariae dextra et sinistra), which supply blood to the heart, begin below the upper edge of the semilunar valves, from the bulbar aorta. During systole, the coronary arteries are obstructed by open semilunar valves, which prevents blood flow. Therefore, the heart is supplied with blood during diastole.

Aortic arch (arcus aortae)

It has the shape of an arch curved upwards. It begins in the truncus brachiocephalicus from the II right sternocostalis and ends opposite the IV thoracic vertebra, where it passes into the descending aorta. With age, the upper edge of the sternum descends to several thoracic vertebrae. A small narrowing occurs at the transition point - the aortic isthmus (istmus aortae). The average length of the arch is 4.5-7.5 centimeters, with a diameter of 2-3.5 centimeters at the beginning and 2-2.5 centimeters at the end.

Three major blood vessels branch off from the aortic arch (from right to left):

truncus brachiocephalic (truncus brachiocephalicus);

left common carotid artery (a. carotis communis sinistra);

left subclavian artery (a. subclavia sinistra).

The brachiocephalic trunk divides into two branches: the right common carotid artery and the right subclavian artery. Carotid arteries and their branches supply blood to the tissues and organs of the head and neck. The subclavian arteries and their branches supply blood to the organs and tissues of the thoracic and upper organs.

Descending aorta

The descending aorta is the longest part of the aorta. Its total length is approximately 30 centimeters, and its diameter is 2-3 centimeters. The descending aorta begins at the level of the fourth thoracic vertebra, continues to the level of the fourth lumbar vertebra, and ends with the bifurcation of the aorta (bifurcation of the aorta). At the point of bifurcation (bifurcatio aortae), the aorta divides into two branches: the common right and left iliac arteries (aa. iliaca communis dextra et sinistra). The descending aorta consists of two parts: the thoracic and abdominal aorta. (*Graduated from the Faculty of General Medicine of the Kishinev State University of Medicine and Pharmacy named after Nikolai Testemitsanu. She completed a residency in the specialty "Anesthesiology and Intensive Care." Author: Tamazlikaru Yu. A.*).

Modern diagnostics of changes in the aortic vessel under the influence of external and internal factors.

The thoracic aorta begins at the level of the aortic valve at the exit of the left ventricle and continues to the level of the diaphragm. Like all arteries, the aortic wall consists of three layers. The inner layer is the intima. The middle layer is called the "media" and consists of smooth muscle cells. One of the instrumental diagnoses for determining normal and pathological states of these conditions is computed tomography (Fig. 4).

Normal anatomy of the aorta on CT angiogram. (A) Axial T-angiogram of the normal ascending and descending aorta. The diameter of the thoracic aorta normally does not exceed 4 cm. (B) On the oblique-sagittal CT angiogram, the normal thoracic aorta, extending from the root of the aorta to the diaphragm, is contrasted in the projection of maximum intensity. Three vessels originate from the aortic arch, usually arranged in the following order: the right brachiocephalic (straight arrow), left common carotid (triangular arrow), and left subclavian (flexible arrow) arteries. (https://meduniver.com/Medical/pulmonologia/metodi-diagnostikiaorti.html.MedUniver).

Reposition of the aortic vessel is observed in some individuals. Normal anatomical variants of the aortic structure. In 7% of people without complaints, the left vertebral artery originates directly from the aortic arch.

Usually, such a variant has minimal clinical significance, but it is useful to know about it when planning catheter angiography or another operation.

Another common variant is the outflow of two branches from the aortic arch instead of three, in which the brachiocephalic and left common carotid arteries originate from a single branch. This variant of the structure occurs in 25% of healthy individuals (Fig. 3). Such a variant received the name of the bull's arch of the aorta, which is generally incorrect, since in cows the aortic arch gives only one branch - the brachiocephalic trunk, from which the subclavian arteries and the bicarotid trunk already begin (Fig. 5)

Figure 5. The aortic arch, which produces two branches. (A) in the projection of maximum intensity on the oblique-sagittal CT angiogram and (B) on the contrast MR angiogram of two different patients, the aortic arch gives two branches: the right brachiocephalic and left common carotid arteries have a common origin (arrows).

Figure 4.

Figure -5

In approximately 0.5% of people, the right subclavian artery originates directly from the aorta. In these cases, its origin is located distal to the origin of the left subclavian artery, and the artery itself is located aberrantly retroezofagially in the mediastinum. Another common variant of the aortic arch structure is the diverticulum of the arterial duct located at the level of the cervix. This localized anomaly of the vascular wall may be complicated by aneurysmal dilation of the diverticulum. False coarctation of the aorta is observed when the aorta is stretched. In such cases, the excess segment of the aorta bends, creating a narrowing of the lumen. This narrowing of the duct can resemble focal stenosis or congenital coarctation of the aorta. Pseudocarctation of the aorta is most often observed in patients with Turner syndrome, in whom it occurs as a result of elongation of the transverse part of the aortic arch. The cervical aortic fossa extends above the level of the clavicle of the aorta to the level of the superior thoracic aperture. Such finding may be a single anomaly or may be accompanied by other congenital anomalies of heart and/or thoracic development.

Errors in assessing the anatomy of the aorta. Pseudocoarctation or true coarctation. True coarctation is a congenital narrowing of the aorta that occurs in the cervical region (at the level of the arterial duct). Therefore, true coarctation hinders blood flow. Secondary signs of coarctation include left ventricular hypertrophy and dilation of collateral vessels, including intercostal and internal thoracic arteries. Pseudocoarctation occurs as a result of elongation and dilation of the aorta. Aortic flexures lead to narrowing of the lumen, although true blood flow obstruction is not observed. Therefore, there is no collateral network of vessels here, and on phasecontrast MRI, blood flow appears normal. Therefore, diagnostics should be carried out with high accuracy.

Magnetic resonance imaging (MRI)

MRI is used to detect structural changes in blood vessels, including thickening or thinning of the aortic wall. This method is considered safe, without ionizing radiation.

Ultrasound Doppler examination

Doppler ultrasound is used to measure blood flow and detect disorders of blood flow within the aorta. This method allows for non-invasive, fast, and convenient diagnostics.

Angiography

A method of visualizing blood vessels using a contrast agent, showing the precise position of the aorta and its branches. This method is more invasive and is often used before surgery.

Conclusion: We can know the morphology of the development of the aortic vessel and the probability of developing anomalies in it. The influence of various influences at different periods can lead to the development of the anomaly.Modern diagnostics

of the aortic artery includes such methods as high-resolution imaging (CT, MRI), ultrasound Doppler examination, and angiography. These methods allow for the early detection and effective treatment of aortic diseases. Proper organization of the diagnostic process is important for improving the patient's quality of life and reducing complications.

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