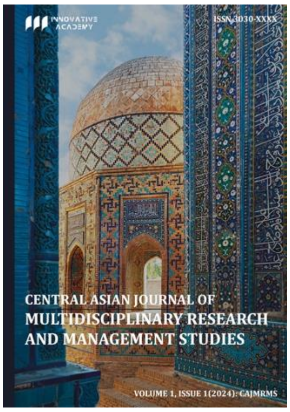

FUNCTIONAL AND CLINICAL ANATOMY OF THE HEART. AGE-RELATED CHANGES, DEVELOPMENTAL ANOMALIES. AORTA

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ABSTRACT

The aorta is the largest artery in the human body. Its origin is the aortic orifice of the aortic valve and ends at the level of the fourth lumbar vertebra. The main function of the aorta is to transport oxygenated blood to supply all organs and cells. With age, structure and therefore function undergo progressive changes. Various changes in aortic morphology include aortic lumen diameter, entire aortic length, thickness, and changes in microstructural components including collagen, elastin, and smooth muscle cells. In addition, the size of all aortic segments increases with age in both sexes. Because age is a major risk factor for degenerative changes and diseases affecting the aorta, understanding the detailed anatomy of the aorta can provide important information about age-related processes in the aorta. Knowledge of the morphological changes in the aorta is also important for future clinical treatments of aortic diseases. Additionally, information about structural changes with age can be used to determine age. This review provides an overview of aortic anatomy, age-related changes in aortic morphology, and aortic diseases.

Introduction. Aging is a complex process that affects overall organ function and structure, leading to progressive changes in organ dysfunction [1,2]. Age is a well-known major risk factor for the development of various diseases, especially cardiovascular diseases (CVD). The prevalence of cardiovascular diseases is increasing worldwide [1,3]. The prevalence of cardiovascular diseases increases with age and usually affects the older age group [4]. Therefore, this means that these age-related changes contribute to cardiovascular dysfunction and lead to clinical impairments. In the cardiovascular system, the main structures of age-related changes are in the heart, heart valves and vascular system. In the vascular system of the human body, the aorta is the largest artery and belongs to the type of elastic arteries. It originates from the left ventricle at the level of the aortic valve of the heart and ends at the level of the bifurcation of the common iliac arteries. The main function of the aorta is to carry oxygenated blood from the heart throughout the body. Generally, the aorta is divided into three main sections determined by their location, that is, the ascending aorta, the aortic arch and the descending aorta. The descending aorta is divided into the thoracic aorta and the abdominal aorta. At the microscopic level, the arterial wall is composed of three distinct layers called the tunica intima, tunica media, and tunica adventitia, from the inner surface to the outer layer. Changes in the human aorta with age usually occur, affecting the structural and functional properties of the wall. There have been many studies of age-related changes in the aorta and it has been found that diameter, length and thickness, including the composition of the tissue in the aortic wall, may be affected. These studies have shown that lumen diameter increases progressively with age [5,6]. As for the thickness of the aortic wall, there are age-related structural changes in the intima and tunica media. Studies have shown that these two layers gradually increased with age [7,8,9,10]. The histology of the aortic wall also changed with age. Collagen, elastin and smooth muscle cells are the main tissues of the arterial wall. The composition of these tissues has changed both in quantity and in their organization in each lining of the aortic wall [11]. Enlargement, elongation, and stiffness of the arterial wall cause an increase in blood pressure [12]. In the review, we describe the anatomy of the aorta, age-related changes in the aorta, including diseases affecting the human aorta.

Anatomy of the aorta

The aorta is the largest vessel in the body. The main function is to transport oxygen-rich blood from the heart to various organs of the body. The aorta originates from the left ventricle of the heart, extends upward into the chest to become the aortic arch, and then down into the abdominal cavity and branches into the common iliac arteries above the pelvis. The aortic root is the part of the aorta that attaches to the heart. The aortic valve is the main part of the aortic root that allows blood to flow from the heart to the rest of the body when it is open. In addition, the aortic valve prevents blood from flowing back into the heart when it is closed. The blood supply to the cardiac tissue that makes up the majority of the heart itself, the left and right coronary arteries, are branches of the aortic root, providing the tissue with oxygenated blood.

The length of the ascending aorta is about 5 cm. It begins in the upper part of the base of the left ventricle, at the level of the lower edge of the third costal cartilage behind the left side of the sternum. The ascending aorta runs obliquely upward, forward and towards the axis of the heart, which is at the same level of the second right costal cartilage. It is located behind the posterior surface of the sternum before the transition to the aortic arch. The aortic arch begins at the level of the upper edge of the second sternocostal joint on the right. First it goes up, back and to the left, passing in front of the trachea. It then travels back along the left side of the trachea and passes down the left side of the body to the T4 vertebra at the inferior border, where it becomes a continuation of the descending aorta. The superior border of the aortic arch is approximately 2.5 cm below the manubrium [13,14]. Several branches arise from the aortic arch. These are the left carotid artery, the left subclavian artery and the brachiocephalic artery. The left carotid artery supplies blood to the brain on the left side, and the left subclavian artery supplies blood to the upper limb on the left side. The blood supply to the right upper limb, including the right hemisphere of the brain, comes from the brachiocephalic artery. The aortic arch continues to descend into the chest and becomes the descending aorta. This vessel is divided into two parts: the thoracic and abdominal aorta. The first is the thoracic aorta, located in the posterior part of the mediastinum, starting to the left of the lower edge of the T4 vertebra and then descending from the left side of the T5-T12 vertebrae into the chest. Finally, it ends at the level of the aortic opening of the diaphragm, which is the point of separation of the thoracic and abdominal cavities. At this point, it is located on the left side of the spinal column and supplies blood to the muscles of the chest wall and spinal cord. A continuation of the thoracic aorta is the abdominal aorta, which enters the abdominal region through the aortic foramen located in front of the lower edge of the T12 vertebral body. It then descends anterior to the spinal column and ends at the level of the L4 vertebral body. Finally, the abdominal aorta divides into the right and left common iliac arteries, located above the pelvis. There are paired visceral branches: suprarenal arteries, renal arteries and gonadal arteries (ovarian or testicular). Then come the arteries which are the unpaired parietal branches from this aorta which include the median sacral artery and the paired parietal arteries which are the subcostal arteries, the inferior phrenic arteries and the lumbar arteries. The end of the abdominal aorta then bifurcates to form the common iliac arteries, which carry blood to supply the lower extremities and various pelvic structures [13,14].

There are three main types of arterial vascular system. The first type includes elastic arteries, which include the aorta, common carotid artery, brachiocephalic trunk, pulmonary arteries and subclavian artery. The second type is the distribution branches known as muscular arteries: radial, femoral, coronary, cerebral arteries, etc. The third type is arterioles, which are the terminal branches of the vessels [15].

Age-related changes in the aorta, both macroscopically and microscopically, are well documented. However, there are few studies describing changes in both gross morphology and histological composition, especially in the normal human aorta. Unfortunately, there are no studies on age-related changes in the aorta in the Thai population. Therefore, we aim to explore changes in the overall morphology and microstructural composition of normal human aorta associated with aging in our future studies. Recently, computer programs such as image analysis tools and artificial intelligence have been widely used. This is because this software is user-friendly and cost-effective and is a non-invasive approach. It may be of interest to measure aortic morphometric parameters using image analysis software and investigate the relationship between aortic morphology and age. The difference in aortic diameter, circumference, and mean aortic thickness can be measured using an image analyzer. Regarding histological studies, it would be better to examine the thickness of the tunica intima and tunica media, and to quantify the major components of the aortic wall, particularly collagen and elastin, including glycosaminoglycans, using image analysis and artificial intelligence. Information about the morphology of the human aorta may also be important in the future for the fabrication of vascular prostheses. In addition, the correlation between age and aortic morphology can be used to determine aortic age in Thais or any other population.

Conclusion

Manifestations of the aging process affecting aortic structures can be detected in changes in aortic diameter, aortic circumference, thickness and total length of the aorta. The lumen diameter and total length of the aorta progressively increase with age in both sexes. The thickness of the tunica intima and tunica media of the aortic wall also increases with age. This thickening of the aortic wall can reduce the elasticity of the vessel and is also associated with the synthesis of many components within the arterial wall. With age, there is a decrease in the number of elastic fibers and smooth muscle cells in the tunica media and an increase in the number of collagen fibers. Therefore, analysis of aortic morphology and microstructural composition of the human aorta associated with age-related changes is critical for future clinical management of aortic pathology and as an age-related indicator.

References:

1. Webb R.K., Insho E.V. Age-related changes in the cardiovascular system. In: Ayyagari V., Gorelik P.B., editors. Clinical hypertension and vascular diseases: hypertension in the elderly. Totowa, NJ: Humana Press; 2005. pp. 11–21. [Google Scholar]

2. Karavidas A., Lazaros G., Tsiachris D., Pyrgakis V. Aging and the cardiovascular system. Hellenic Jay Cardiol. 2010;51:421–427. [PubMed] [Google Scholar]

3. Fleg J.L. Changes in the structure and function of the cardiovascular system with age. I'm J Cardiol. 1986;57:33–44C. [PubMed] [Google Scholar]

4. Redey A., Yu W.K., Musso E., Harouni A.A., Kachenura N., Wu SO, Blumke D., Lima J.A. Age-related changes in aortic arch geometry: relationship with proximal aortic function, mass, and left ventricular remodeling. J Am Coll Cardiol. 2011;58:1262–1270. [PMC free article] [PubMed] [Google Scholar]

5. Gerstenblit G., Frederiksen J., Yin F.K., Fortuin N.J., Lacatta E.G., Weisfeldt M.L. Echocardiographic assessment of the normal adult aging population. Circulation. 1977;56:273–278. [PubMed] [Google Scholar]

6. Xu X, Wang B, Ren S, Hu J, Greenberg DA, Chen T, Xie L, Jin Q. Age-related disorders of vascular structure and function. Aging Dis. 2017;8:590–610. [PMC free article] [PubMed] [Google Scholar]

7. Virmani R., Avolio A.P., Mergner W.J., Robinowitz M., Herderick E.E., Cornhill J.F., Guo S.Y., Liu T.H., Ou D.Y. ., O'Rourke M. Effect of aging on aortic morphology in populations with high and low prevalence of hypertension and atherosclerosis. Comparison of Western and Chinese communities. I'm Jay Patol. 1991;139:1119–1129. [PMC free article] [PubMed] [Google Scholar]

8. Nagai Y, Metter EJ, Early SJ, Kemper MK, Becker LK, Lacatta EG, Fleg JL. Increased intimal medial carotid thickness in asymptomatic older adults with exercise-induced myocardial ischemia. Circulation. 1998;98:1504–1509. [PubMed] [Google Scholar]

9. Laurent S. Determination of vascular aging and cardiovascular risk. J. Hypertens. 2012;30(Suppl):S3–S8. [PubMed] [Google Scholar]

10. Collins JA, Muñoz JV, Patel TR, Lucas M, Tubbs RS. Anatomy of the aging aorta. Klin Anat. 2014;27:463–466. [PubMed] [Google Scholar]

11. Cheuk B.L., Cheng S.V. Alpha5beta1 integrin expression and relationship with collagen and elastin content in the human adrenal and infrarenal aorta. Vascular endovascular surgery. 2005;39:245–251. [PubMed] [Google Scholar]

12. Acquaro G.D., Cagnolo A., Tiwari K.K., Todiere G., Bevilacqua S., Di Bella G., Ait-Ali L., Festa P., Glauber M., Lombardi M. Age-related changes Elastic properties of the thoracic aorta assessed using magnetic resonance in normal subjects. Interact Cardiovascular thoracic surgery. 2013;17:674–679. [PMC free article] [PubMed] [Google Scholar]

13. Moore K.L., Dally A.F., Agur A.M. Clinically oriented anatomy. 7th ed. Philadelphia, PA: Wolters Kluwer Health/Lippincott Williams & Wilkins; 2013. [Google Scholar]

14. Drake R., Fogl A.V., Mitchell A.V. Gray's Anatomy for Students. 2nd ed. Philadelphia, PA: Elsevier Health Sciences; 2009. [Google Scholar]

15. Gartner L.P., Hiatt J.L. Color atlas and text of histology. 6th ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2013. [Google Scholar]