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Considerations on structural organization of the aorta

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Abstract

Background: This article deals with a number of structural features of the human aorta which arouse great interest for clinicians recently. The following items were highlighted: a) the dependence of the aortic morphology upon the constitutional body types; b) the impact of aortic structural features on its affections; c) functional anatomy of the fat pads; d) glomic structures of the aorta; e) location of the reflexogenic areas of the aorta; f) some specific features of aortic syntopy; i) urgent need to improve terminology.

Material and methods: The study was performed on subjects coming to autopsy not more than 24 hours after death. Their mean age was from 16-week fetuses up to 96 years. A number of research methods have been used: morphometry, histological examination, immunohistochemical method, coloring with Schiff reagent, injectional investigation and anatomical preparation. A total of 354 human aortas were examined: 109 of them were selected for morphometry; 40 - for histological examination, 40 – for coloring with Schiff reagent, 20 – for injectional investigation; 69 mediastinal complexes were subjected to anatomical preparation. The presence of the lymph vessels in the wall of the aorta was confirmed by means of immunohistochemical method.

Results: Dependent and non-dependent gender, age and body type characteristics of the aorta was revealed. Special attention was paid to applied aspects of clinical importance related to the ascending aorta and aortic arch.

Conclusions: Relationship between aortic morphology and body types was revealed. The variability of the shape, size, location and contents of the fat body of ascending aorta was described. Macroscopic and microscopic structural specific features of the aorta were studied from the point of application.

Key words: aorta, fat body, vasa vasorum, glomus, reflexogenic zone, lymph collector.

Introduction

There is hardly to name another blood vessel in human body whose morphology has been so largely reported in scientific papers, as aorta. It seems as if everything is already known: its ontogenesis, morphogenesis, macro- and micro-structures, properties of its walls, sources of nerve supply and blood supply. The major anatomic structures of the heart and aorta have been well described, documented and named. Two aspects attract attention here:

- Multitude of articles published by clinicians, especially cardiosurgeons, from many countries who treat heart and aortic diseases, deal with problems of the lack of morphological evidence which lead to postoperative complications and the ways to prevent them.
- At the same time, articles on the morphology of the aorta have been published rarely for the last two decades.

Having studied more than 800 scientific papers on the morphology and physiology of the aorta, it is surprising, that today, there are many uncertainties in this field of study.

Today, a frequent use of the word "enigma" in description of the heart and aorta by clinicians and anatomists means insufficient studies of these central links of the circulatory system. Multitude of articles published by clinicians, especially cardiosurgeons, from many countries who treat the diseases of the heart and aorta deal with the problem of the lack of morphological evidence that lead to a number of postoperative complications and the ways to prevent them.

Aorta is an essential component in biomechanics of the circulatory system, which has increasingly drawn the attention of the physicians. The available data, regarding the morphological organization of this magistral blood vessel are no longer sufficient to solve practical problems, since cardiovascular diseases have become a leading cause of death; the ageing of the population accounts for the increased risk of these diseases, respectively. Certain structural elements of the aorta, which until recently showed no interest, are of great clinical importance, at the moment, as well as their study and have become particularly actual, nowadays. The shape and parameters of various portions of the aorta, as well as, the relations between them should be considered in surgical planning and performing of this vessel plasty. Their studies are necessary for understanding the pathogenesis of the aortic diseases.

Early achievements of 1967 in cardiovascular field, including morphological aspects, made the first heart transplant possible. At present, the advanced cardiovascular surgery requires new studies in morphology. Despite the unprecedented advances in diagnosis and treatment of cardio-aortic diseases, cardiovascular diseases have become the leading cause of death in both industrialized and developing countries. This fact has been confirmed by statistics on all the continents. Thus, the cardiovascular diseases mortality rate, in 2010 made up 39.1% in the EU countries, while 60.2% in Romania and little more in Moldova – 66.7%. Furthermore, the peculiarity of these diseases suggest a very high risk of disability in population. Indisputably, the aging process is associated with increased risk of cardiovascular diseases, while recent population research estimates 197.9 million of elderly and senile population in Europe by 2025, which makes up 11% and 78.5% higher than in 2010 and 1975, respectively. This fact suggests that situation will get worse.

The incidence of postoperative complications, some lack of their morphological evidence, articles in the third millennium, such as: "The Enigmatic Cardiac Fat Pads: Critical but Underappreciated Neural Regulatory Sites" [1], "Postoperative atrial fibrillation: a billion-dollar problem" [2], "Postoperative Atrial Fibrillation and Mortality: Do the Risks Merit Changes in Clinical Practice?" [3], "The mystery of aortic dissection: a 250-year evolution" [4], "Atrial fibrillation after cardiac surgery" [5]; contradictory discussions regarding subjects like "Crista aortae ascendentis, ascending aortic fold or Rindfleisch's fold – an enigma" [6, 7, 8, 9, 10]; statistics indicating that cases of postoperative atrial fibrillation have doubled and, in some countries, tripled over each past decade [5, 11, 12] and other facts - all these served as an impetus for the present study.

Material and methods

The study was performed on subjects coming to autopsy not more than 24 hours after death. Their mean age was from 16-week fetuses up to 96 years. A number of research methods have been used: morphometry; histological examination, immunohistochemical method, coloring with Schiff reagent, injectional investigation and anatomical preparation. A total of 354 human aortas were examined: 109 of them were selected for morphometry; 40 - for histological examination, 40 – for coloring with Schiff reagent, 20 – for injectional investigation; 69 mediastinal complexes were subjected to anatomical preparation. The presence of the lymph vessels in the wall of the aorta was confirmed by means of immunohistochemical method.

Results and discussion

The present information is a fragment of a comprehensive study of the morphology of the aorta conducted for the last 12 years. In the presented study, there was determined a wide variability of morphological organization of various portions of the human aorta. There were identified some regularities. Thus, the length of different portions of the aorta depends on the constitutional type of human body: the mean length of the ascending and descending portion is greater in asthenics than in normosthenics and hypersthenics, whereas the longest arch was detected in hyperstenics. The diameter of the aorta increases with aging for both genders, by a mean value of 1.9 mm over each decade.

At readers disposal, there are shown research results on fat body of the ascending aorta (FBAA), size, location (fig. 1) and degree of its development based on gender and age, information which is presented via tables and charts. In 78% of cases, simple bodies are found more frequently than the compound ones, (women - 75%; men - 82.5%). The commonest shape of this fat structure is the strip (in 32.9% of cases: 28.8 - men, 39.4% - women), the rarest form is fold (in 10.8% of cases: 9.6% - men, 12.1% - women). The forms of crest, cylinder and fat pad represent 18.6%, 17.6% and 20% of cases, respectively. Incidence of crests are three times more common in males than in the opposite sex. The strip and fat pad incidence is higher in women than in men by 25% and 13%, respectively (tab. 1).

Regarding the compound bodies, they were found in 22% of the total number of observations, 70.8% - in men; 29.2% - in women. There were detected 10 combinations (tab.2). The most common are presented by strip-cylinder (in 25.0% of cases: 3.7 more frequent in women), followed by cylinder-fat pad and pad-crest (in 16.7%). Requiring notes: it has been observed cylinder-pad is 2.4 times more common in women, and crest-pad has been found only in males (tab. 2). No case of cylinder-fold was deteted. The variability of these compound bodies is larger in men (9 variants) than in women (only 4).

The mean data of morphometric examination of 109 cases of particularities, regarding the length of adipose body and based on gender, differ very little. The average length of FBAA is 3.41 cm in males and 3.43 cm in women.

Up to the age of 35, this index shows no obvious gender difference. It varies in different age periods: the length of the FBAA is the same in women, during 19-35 years and after 66 years; in the second period of adulthood (36-65 years) it is only 2.76 cm; the length of fat body, practically does not vary in men of the first two periods, while group III is smaller. A wide range of minimum and maximum values is observed in men: in the Ist group, the maximum value exceeds 3.75 times the minimum; in the IInd group – 7 times; group three - 5.3 times.

Table 1

Simple FBAA incidence in men and women (%)

Shape	str	cl	cr	fl	fp
Men	28.8%	19.2%	26.9%	9.6%	15.4%
Women	39.4%	18.2%	9.1%	12.1%	21.2%
Mean Incidence	32.9%	18.6%	20%	10.6%	17.6%

Note: str – strip; cl – cylinder; cr – crest; fl – fold; fp – fat pad.

Table 2

Incidence of compound FBAA (%)

	str/cl	str/cr	str/fl	str/fp	cl/fp	cl/cr	cr/fp	fl/fp	str/cl/fl	str/cl/fp
Men	11.8	5.9	17.6	5.9	11.8	5.9	23.5	0	5.9	5.9
Women	42.8	14.3	0	0	28.6	0	0	14.3	0	0
Mean Incidence	25.0	8.3	12.5	4.2	16.7	4.2	16.7	4.2	4.2	4.2

Note: str/cl – strip-cylinder; str/cr – strip-crest; str/fl – strip-fold; str/fp – strip-fat pad; cl/fp – cylinder-fat pad; cl/cr – cylinder-crest; crest/fat pad; fold-fat pad; str/cl/fl – strip-cylinder-fold; str/cl/fp – strip-cylinder-fat pad.

Fig. 1. Variability of the ascending aorta fat pads. 1 – fold, 2 – horizontal crest, 3 – vertical crest, 4 – fragmented fat pad, 5 – fat pad on the posterior surface of the ascending aorta, 6 – fat pad on the right surface of the ascending aorta, 7 – bundle, 8 – bundle-fold, 9 – bundle-pad.

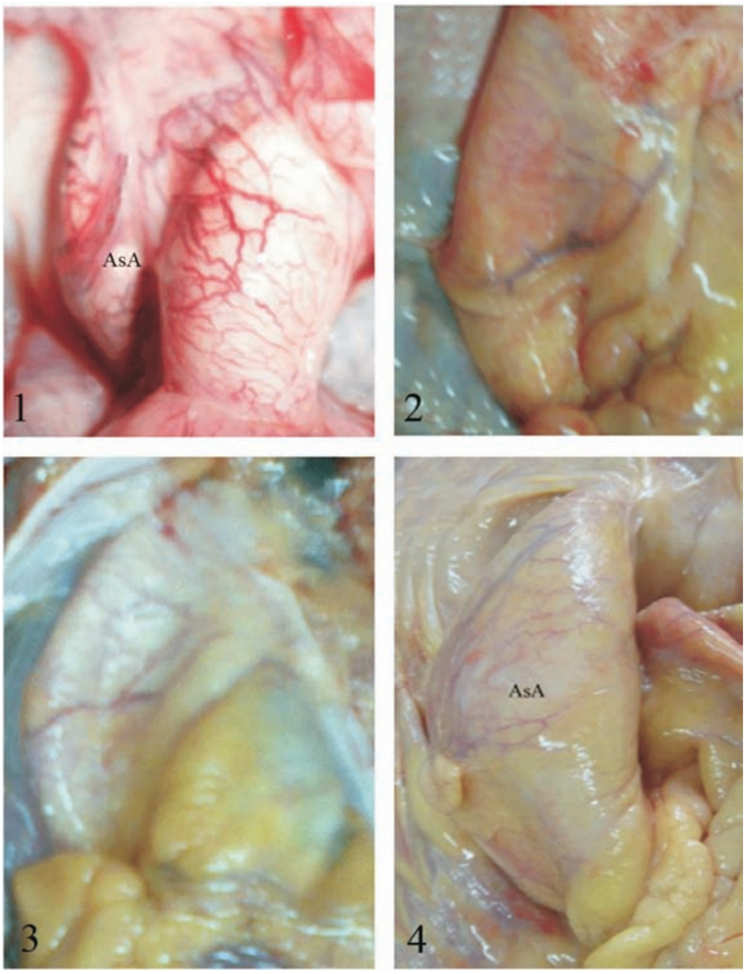

Fig. 3. Vasa vasorum internae of the ascending aorta.
1 – Ascending aorta and pulmonary trunk of the fetus of 29 weeks,
2 – Woman of 50 years, 3 – Man of 61 years, 4 – Man of 59 years.

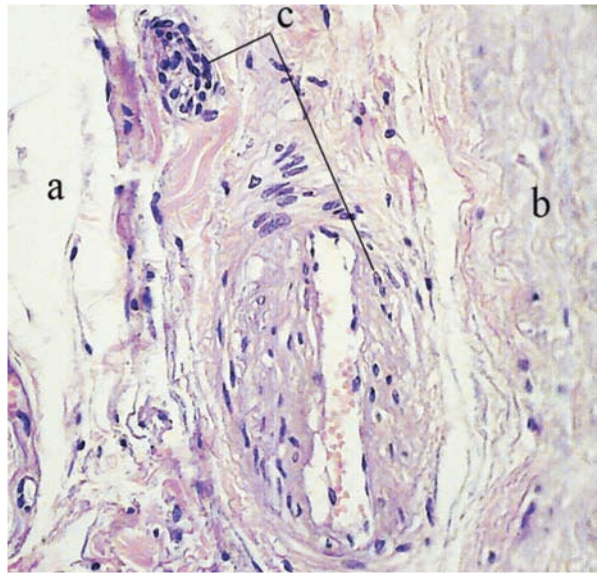

Fig. 5. Glomic cells of the ascending aorta in deep layer of the adventitia. a – adventitia, b – aortic media, c – glomus cells.

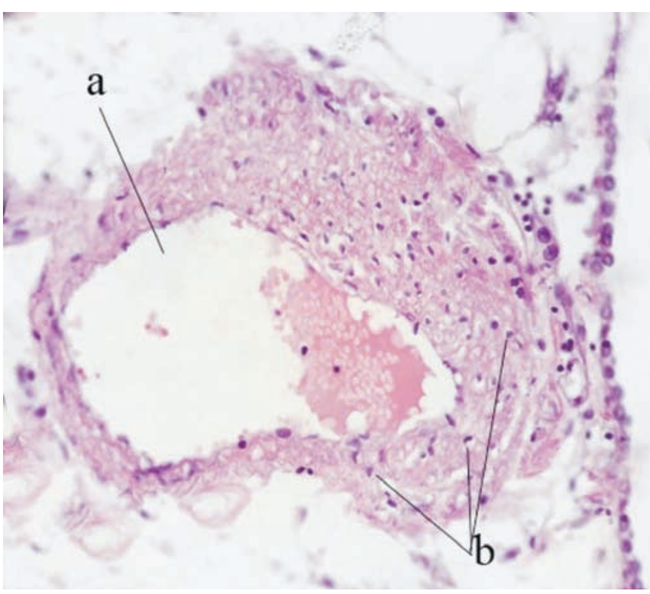

Fig. 4. Glomic cells of the ascending aorta.
a – vein, b – glomus cells.

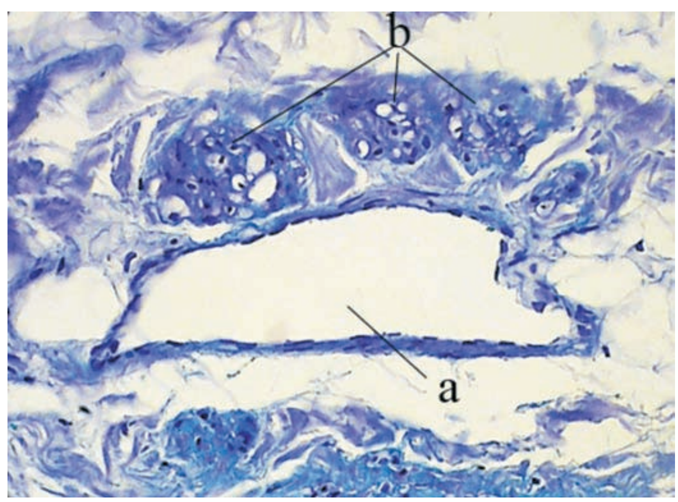

Fig. 6. Glomic cells of the ascending aorta.
a – lymph vessel, b – glomus cells.

The biggest difference in the opposite gender representatives was found in group II - 6.8 times, in group III - 4.6 times, and the Ist – only 1.2 times.

Even more interesting data are obtained through analysis of the length of the fat body of ascending aorta in different age decades (fig. 2). Up to the age of 30 there is no significant difference in FBAA length regarding gender. Subsequently, by the age of 40-41, a sudden increase occurs in males, while a decrease is observed over the next decade; ultimately, a stagnation occurs up to the age of 60-61. Subsequently, a sudden decrease may come.

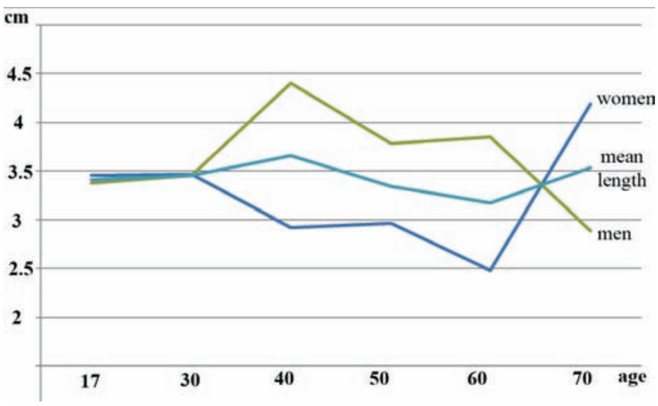

Fig. 2. The mean length of FBAA.

In women aged over 40, the dynamics of fat body size occurs directly opposite: the decrease- up to 50 years old; stagnation - up to 60; sudden decrease - untill 61 is followed by a sharp increase.

At the age of 65, FBAA length values are equivalent in both genders, whereas the index continues to rise to its maximum in women, and decrease until the minimum index in men.

The highest values of ascending aorta fat body length (7.0 cm) were found in males aged from 52 to 65, both deaths occured due to cardiovascular disease. By the way, the other cases which were observed (length more than 6.5 cm), also belong to the deceased men aged 52, 54 and 57 years, with similar causes of death. The maximum indices were recorded in females aged 57 and 77 years old, deceased as a result of myocardial infarction and acute cardiovascular disease.

Hence, the persons do not differ either in age or diagnosis. All of them suffered from right atrial hypertrophy.

It is obvious that, the level of development of the aortic fat body does not correspond to the development of the adipose tissue in general. We have observed cases when the aortic fat bodies are well-developed in cachexia, and vice versa, less-developed in obese people.

Most common FBAA starts from the anterior aortopulmonary groove and continues on the anterior and right sides of AA's, especially in women (in 39.5% vs. 31% in men). Then, it is followed by the location of fat body mentioned only on the right side of ascending aorta (in 16.6% ; 1.4 times more common in males); on the anterior and right sides (in 12.8% ; 3.2 times more common in men). A larger fat body which made up 60%, and in some cases more, out of the AA's circumferential length was found in 2 cases, more common in males. The location of FBAA only on the posterior surface was recorded only in males (in 4.2% of cases), and only on the anterior part and in fragmented form (the location on anterior and posterior surfaces) - only in women (in 7.9% and 2.6% of the cases, respectively).

Table 3 demonstrates conclusively the lack of interdependence between the development degree of the AA's fat body and overall fat body. Regarding the development of FBAA degree, extreme variations were detected: poorly-developed adipose bodies were found in men, and well or very well-developed degree predominantly in the opposite sex.

Regarding the above mentioned we can conclude that the location of FBAA is determined by the shape of the right auricle and the degree of development depends upon the force of contraction of the right atrium.

The very shape of the crest dominance and the combinations including it in men and strip and fat pads in women indicates the interdependence between formation of specific type of FBAA and atrial contraction power. In determining the fat body appearance both the auricle shape and the configuration of its contact line with the ascending aorta are important.

What is the most primary: the formation of vasa vasorum internae (VVI) of fat body area or fat body? Figure 3.1 shows that, in absence of fat deposits during the prenatal development, VVI direct towards the common location of the fat body of the ascending aorta. In adults, the fat body is formed and can be seen with naked eye, VVI are directed to the fat body, regardless of its location: on the anterior surface (fig. 3.2), on the lateral (fig. 3.3) or posterior (fig. 3.4). Since, everything is a logical part of nature, this can be only explained by the existence of functionally important structures at this level, which requires a rich vascularization, while the adipose tissue performs auxiliary functions, more likely those of supporting and buffering. Our microscopic study shows that the vasa vasorum internae ensure the vascularization of the structures

Table 3

Degree of development of the fat tissue

	Very low		Low		Moderate		High		Very high	
	FBAA	GFT	FBAA	GFT	FBAA	GFT	FBAA	GFT	FBAA	GFT
Women	0%	2.5%	32.5%	7.5%	15%	52.5%	30.0%	25.0%	22.5%	12.5%
Men	4.3%	1.4%	17.4%	7.2%	11.6%	46.4%	39.1	29.0%	27.5%	15.9%
Mean	2.8%	0.9%	22.90%	7.3%	12.8%	48.6%	35.8%	26.6%	25.7%	27.5%

Note: FBAA – fat body of ascending aorta; GFT – general fat tissue.

similar to the carotid corpuscle that are located within the fat body of the ascending aorta.

It is natural, that the adipose tissue, while diminishing the systolic shocks of atrial auricles and the pulsating ones during the contractions of the left ventricle, provides optimal conditions for the structures involved in regulation of the blood circulatory system.

Glomus cells were found within the fat body of ascending aorta, along the arterial vessels, venous and lymphatic. They were recorded at different depths of aortic adventitia from subepicardic layer (fig. 4) until to the limit of the aortic media (fig. 5). Hence, the glomus structures, which are located in fat body of the ascending aorta, widely vary in shape, size, depth of location and their relation to blood and lymph vessels (fig. 4, 5, 6).

In most cases, glomus cells represent clusters, forming corpuscles. As a rule, the smaller ones are located deeper, near the aortic media. The size of these structures varies from 100 mkm to 2 mm. Along with age, the pseudocapsule becomes more defined (fig. 4), the number of supporting cells also increases.

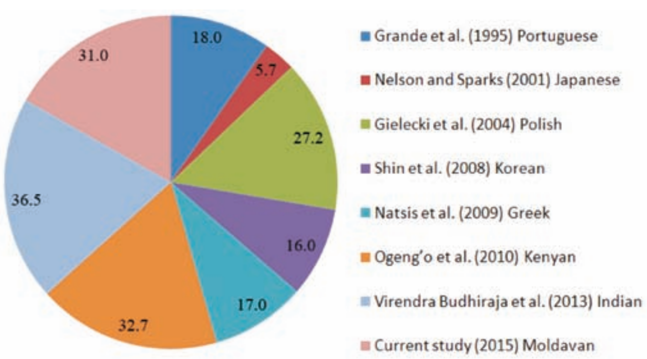

Fig. 8. Frequency of variant branching of aortic arch in different populations (%).

The obtained results prove the permanent presence of multiple rounded or oval lobulated structures with specific sources of vascularization (vasa vasorum internae) inside the ascending aorta fat body. The number and size of lobules are highly variable. The lobules are surrounded by connective fine capsules, containing a variable number of glomus cells. It would not make sense to mention these obvious facts if not applied clinical importance of this fat accumulation and a close relationship between its form and the nature of the vascular net.

The presence of these structures at all ages, specific sources of their vascularization like vasa vasorum internae with origin on the concave side of the ascending aorta, normally 1-1,5 cm above FBAA, which coincides with the location of the reflexogenic area, is described by Iu. C. Comroe [13] in his experimental study; it is reasonable to conclude that reflexogenic area is localized in the fat body of the ascending aorta.

The trajectory of the large lymph collector providing drainage from the sinus node area was described on the base of our mesoscopic study with the use of the Schiff reagent. Histologic and immunohistologic methods allowed us to reveal lymph vessels and nodules in the aortic adventitia.

Studying all the nervous, vascular and lymphatic elements of the fat body of ascending aorta, we came to the conclusion that disruption of the above named collector during the surgical intervention leads to the development of atrial fibrillation in the postoperative period. While studying all divisions of the thoracic aorta we have not managed to reveal such combination of specific features of vascular, lymphatic and nervous apparatus as in the area of FBAA. These observations suggest this anatomical structure to be a functionally important area of the aorta.

Based on a substantial material, accumulated over several years of research, we tried to answer a series of questions which refer to the functional morphology of the ascending aorta, especially of its fat body. Simultaneously, we cannot affirm that the so-called "enigmatic ascending aorta" reported by many clinicians over the last decade, has exposed all its secrets. We revealed typical for endocrine gland tissue and some neurovascular complexes in its fat body contents. What is their function? Such information has not been found in available literature.

Our study shows a lot of anatomical variants of aortic arch. Three shapes of the aortic arch were asserted: roman arch - in 31 of 42 cases (73.6%), gothic arch - in 10 cases (24%) and crenellated arch in one case (2.4%). The atherosclerotic damage in the last two shapes is more pronounced.

The typical ramification into three branches was detected only in 69.05% of cases. The greatest variability of the aorta branching occurs in normosthenics (fig.7). The variants were found in 13 out of 42 cases (30.95%), whereas, 2 branches - in 9.5%; 4 - 19.04%; 5-2.41%. There is a difference compared to other studies of the authors from various countries (fig. 8).

In surgical plasty of aortic arch, postoperative complications appear, such as: damage of the vagus, recurrent laryngeal and/or phrenic nerves, sometimes lymph thoracic duct [14, 15]. There are few publications on morphology regarding this issue, which can be explained by the fact that these complications are not fatal for patients. The actual problem may occur, if the patient has pre-operative respiratory disorders which can worsen the prognosis. The incidence of the above mentioned nerve damage and thoracic duct is not high, but tends to increase, which is explained by the increased incidence of surgical interventions on the organs which are sintopically related to the above-mentioned anatomical formations. Complete information is required with reference to the variability of aorta syntopy and adjacent nerves [16, 17].

The larynx is involved in actions of swallowing, breathing, coughing and phonation. These functions are dependent upon the normal movements of the vocal cords that are controlled by muscles innervated by branches of recurrent laryngeal nerves.

According to the statistics, the recurrent laryngeal nerve palsy is caused by tumors in 1/3 of cases, in 1/3 of the cases – by the trauma and 1/3 of cases – by unknown causes (idiopathic).

The approximate length of the left recurrent laryngeal nerve is 12 cm, whereas the right is only about 6 cm. This distinction explains the fact that the most common subjected to trauma is the left recurrent laryngeal nerve in the chest region. This nerve damage occurs in 11-32% of thoracic surgery. Most publications regarding traumas to this nerve are performed by otolaryngologists who deal with nerve injury on thyroid surgical interventions. Within the chest, the left recurrent nerve shows a close contact with the aorta, the trachea, the left atrium, left main bronchus, esophagus and lymph nodes.

The recurrent left laryngeal nerve, which passes under the arch of the aorta, is placed in tracheoesophageal fascia, in the tracheoesophageal groove above or slightly anteriorly of the above-mentioned groove. Therefore, not only the nerve is at risk during surgery on the aortic arch, but also esophagus, trachea [18]. The damage of the inferior laryngeal nerve leads to the establishment of the respective vocal cord in para-median position; there is a risk of aspiration of heterogeneous bodies into the trachea.

As a rule, the aortic arch plastic surgery, mediastinoscopy, intrapleural analgesia, left lung lobectomy, lymphadenectomy are associated with various complications depending on the individual syntopic peculiarities of the superior mediastinum organs.

The damage of phrenic nerves, vagus and left recurrent laryngeal one and others, arise discussions among clinicians [19-31]. This problem is, usually, referred to morphological changes in some patients. It still has not found the right place in specialized literature. Hence, the knowledge about individual features can help reduce the risk of damage to adjacent organs.

Commonly, the term „aortic arch" stands for a segment of the aorta, which branches off to the head, cervix and upper limbs. According to our investigation results, the aortic arch length ranges from 2.7 cm to 6 cm. We have established an interdependence of body constitution type and length of the arc, but not between its length and number of branches which ramify from the aortic arch, although these individual variations can be frequently seen.

Syntopical relations of the aortic arch, largely correlate with its structure. The aortic arch may be slightly (roman arch) or sharply curved (gothic arch). In the first case the arch branches are more evenly spread, whereas in the second case they start from the shortest upward or downward segment.

The nerves and adjacent vessels correlations and paths vary greatly in different people. We have paid particular attention to the essential moments of faster exposure of nerves and vessels during surgery. Such an approach helps to prevent their trauma, if it occurred – in selecting appropriate neurosurgical technique in neurorrhaphy.

Our study showed variants of aortic arch branching and insertion of arterial ligament, atypical left vagus and recurrent nerve tracts, the existence of the supernumerary trunks of the latter and thoracic duct lymph.

In typical cases, left vagus nerve intersects the upper margin of the aortic arch, placing itself in front of the left subclavian artery, although in 28.57% of cases it passes laterally of this vessel, of which half is 1 - 1.5 cm to the left. The most common lateral placement of the left vagus nerve (LVN) is observed in hypersthenics (50%), in asthenics it is registered in 44.5% of the cases, and in normosthenics – 22.7% of cases.

In 8.16% of cases, LVN passes medially from LSCA at a distance of 3-4 cm. Hypersthenics make up 50% of cases; normosthenics and asthenics the other 50%, 25% respectively for each of the cases.

By the way, the constitutional type was determined by the ratio between the waist and chest perimeter (at the level of the X rib). People with a coefficient up to 0.5 were attributed to asthenics; those within 0.51 to 0.60 to normosthenics; 0.61 and more to hypersthenics.

The inferior edge of the aortic arch is intersected by LVN at a distance of 0.2-1.3 cm laterally from the aortic end of the arterial ligament. In 80% of cases the left vagus passes anteriorly to the aortic isthmus, in 15% of cases - on its medial edge, in 5% of cases – on the lateral edge respectively.

The aortic arch is surrounded all over by the cardiac plexus formed by branches of the sympathetic trunks and of vagus nerves. In the forefront, the aortic arch is covered by the pleura, the anterior edges of the lungs and thymus, except for the middle portion of the arch, which is not covered by the pleura, thus allowing to perform the retrosternal anesthesia of the cardiac plexus. The left phrenic nerve is located anterior-medially to the left vagus nerve. The left intercostal supreme vein passes between these two nerves, which have an oblique direction to the anterosuperior part.

Inferior to the aortic arch, there are 4-6 lymph nodes sized from 0.5-1.0 cm, left pulmonary artery and the left bronchus. The aortic arch intersects them and extends to its descending part. The arterial ligament is located on the anteroinferior half-circumference of the aortic arch. Posteriorly from the arch of the aorta, from right to left, there are the trachea, esophagus, lymphatic thoracic duct.

The brachiocephalic trunk, left common carotid artery and left subclavian artery take their onset from the upper side of the aortic arch to the cranial direction. The incipient portion of the superior vena cava is located toward the right.

The classical description of the correlation between the aortic arch and the structures located on its posterior part is as follows. The posterior part of the aortic arch comes in contact with the anterior wall of the trachea. The esophagus is located toward the left, at the crossing arch of the descending aorta. The recurrent nerve passes through the anterior tracheoesophageal groove, whereas the lymphatic thoracic duct – through the left edge of the esophagus. The recurrent laryngeal nerve contains myelinated fibers. These fibers are placed anteriorly within the vagus nerve.

The recurrent laryngeal nerve fibers begin to rotate medially along the vagus nerve, until are separated from the vagus nerve respectively [19]. The level of separation takes place according to the concave edge of the aortic arch in 67.4% of cases, 15% - in the upper portion of the ventral surface of the arch, in 17.6% of cases - in its lower portion. In most cases, the left recurrent laryngeal nerve (LRLN) passes from the left arterial ligament, being closely allied to the latter; the divergence angle between LRLN and LVN ranging from 20˚ to 85˚ degrees. The existence of the accessory left recurrent laryngeal nerve (ALRLN) takes place in 8.16% of cases, in

3/4 of them - to hypersthenics; in ¼ of cases - to normosthenics and in no case to asthenics. In 50% of cases, ALRLN was detected in association of the aortic arch with three branches, the other 50% - with 4 branches. As it was already mentioned above, in common cases, LRLN is placed in the anterior tracheoesophageal groove or in the forefront of it. The accessory trunk is located toward the front of the trachea in all cases. We found no dependence of this variant neither to the arch length or to type of body constitution. Therefore, surgeons should pay special attention during interventions to hypersthenic patients and occurrence of accessory branches originating from the aortic arch, which can result in reduced cases of recurrent laryngeal nerve trauma and the follow-up consequences that can occur.

The path variations of the left recurrent laryngeal nerve are not common. To alleviate any postoperative complications, cardiothoracic surgeons must know the possible variants. There were cases, where this medial nerve was crossed by the ligamentum arteriosum [32].

Clinicians highlight three areas related to the risk of left recurrent nerve injury:

A. The high risk area of direct injury – toward the front part of the inferior portion of the trachea left wall;

B. The high risk area of indirect injury, induced by compression - between the inferior part of the trachea wall and aorta;

C. Low risk area - along the right wall and in the forefront of the upper portion of the anterior wall of the trachea.

Syntopic relations of the recurrent nerve, as well shows practical interest. In 12% of cases, the left recurrent nerve starts from the ventromedial area of the vagus nerve; in 88% - from the dorsomedial area. Inside the chest, left recurrent nerve is closely allied to the aorta, trachea, left atrium, left main bronchus and esophagus. Under the arch of the aorta, posterior to the Gross triangle (an area limited anteriorly by the phrenic nerve, posteriorly – by the vagus nerve and inferiorly - by left pulmonary artery), the recurrent nerve comes in contact with 3-5 lymph nodes ranging from 0.5 to 1.0 cm. In case if the lymph increases, the nerve becomes essentially flattened, that is 2-3 times thinner (also much wider) compared to the normal state, causing phonetic disorders which are difficult to diagnose.

In 10% of anatomical specimens that have been examined, the recurrent nerve was represented by two or three trunks. According to data of C. Weeks, J. Hinton (1942), this phenomenon is found more frequently - in 78% of cases [33]. The nerve trunks are always distributed toward the frontal part. At the posterior part of the aortic arch at the level of the concave portion, the distance between trunks varies from 2 to 5 mm, but on the convex surface, it increases to 10-14 mm. Some sources describe recurrent laryngeal nerve splitting into two branches (medial and lateral) at the lower limit of the larynx. Probably the inferior division explains the presence of several of the recurrent nerve trunks. In case of supernumerary trunks, one is placed in the anterior tracheoesophageal groove, others - on the front part of the trachea. The fact that all identified additional nerve trunks have been found in humans of hypersthenic body type is of interest.

There is a uniformity: supernumerary trunks of the left recurrent nerve are detected in cases when the left vagus intersects the convex margin of the aortic arch near its origin or at the level of the brachiocephalic trunk. Thus, based on intraoperative viewing of the vagus nerve, we can detect the location of the left recurrent nerve and the existence of accessory nerve, which, in turn, will reduce the risk of their injury and therefore prevent the paralysis of the vocal folds.

According to our observations, the typical location of the left recurrent nerve, in the tracheoesophageal groove, occurs only in 61% of cases. In 39%, it goes 3-10 mm medially from the groove, on the anterior surface of the trachea.

There are other unclear issues which refer to the impact of the aorta morphological organization on the potential exposure of this vessel to various diseases. Although there are various hypotheses of the pathogenesis of atherosclerosis (lipid, response to aggression and to initial, unified, neurogenic, infectious atherosclerotic lesions), yet the risks are known: the gender and genetic factors, age, bad diet, obesity, pollution of air, sedentary lifestyle and others [33]. Taking into account our observations, we can say that other factors also cannot be excluded, like lymphatic drainage and structural features of aorta which affect the hemodynamics of this major vessel.

The study of over 300 intact human aortas, showed their diversity by different criteria, especially in length and diameter. Thoracic and abdominal portions vary both in length as well as in their correlation. A similar situation is asserted at incipient and terminal portions of the lumen of the descending aorta. Under equal conditions (gender, age, constitutional type), the bigger the coefficient values are, the more advanced are the manifestations of atherosclerosis – both extension, as well as its degree of severity. We refer to the length coefficient. It makes up the ratio between the length of the descending thoracic aorta and of abdominal aorta. Lumen value is the ratio between the lumen of the descending aorta in its incipient portion (upper chest) and of the terminal portion (lower abdominal).

The above-mentioned indices are not the major determinants of atherosclerosis onset and pathogenesis, but both have impact on the aortic hemodynamics. It should be noted that, while examining various morphological aspects, we should as well consider the conditions of the hemodynamics.

A difficulty which arose during our research, just at the early stage of studying the specialized literature referred to terminological differences in publications on the topic. The terms used in describing portions of the aorta and its components at the macroscopic and microscopic level are very variable. F. Unger and et al., described the need to improve terminology of adipose bodies of the aorta [34]. We studied several aspects of aortic morphology and consider the problem of terminology as an acute one which can affect people's lives.

In order to avoid double or even triple interpretation of the presented data, we believe that we need to clarify the used terms. The authors unanimously use the term of "ascending aorta" in describing the aorta, although this notion defines different meanings. According to some data (Clinical Anatomy Associates, 2015), the ascending aorta ends on imaginary

Table 4

Terms used for fat body of ascending aorta

Authors	Terms
E. Rindfleisch (1884)	Semilunar fold, ridge, vincula
Z. Davis. (1927)	Periaortal fat body
K. Smetana (1930)	Fat ring
H. F. Robertson (1930)	Periaortal fat pad
W.W. Parke, N.A. Michels (1966)	Aortic ridge
G. T. Lebona (1991)	Ascending aortic fold
L. Gross (1921), Z. Davis (1927), F. Unger, W.Gerald Rainer (1999), George Falkowski, Ilya Dzigivker, Dani Bitran (2001)	Transverse fold
Zev Davis, H. Kurt (2000, 2004)	Aortic fat pad
G. T. Lebona (1993)	Ascending aortic folds: oblique, horizontal, vertical, oval, horizontal-oblique, vertical-oblique, vertical-horizontal, vertical-horizontal-oblique, oval, oblique.
J. J. Morrison, M. Codispoti, C. Campanella (2003)	Transverse ridge
Felix Unger (2005), J. J. Morrison (2003)	Fold, crest

horizontal line that passes through the sternal Louis angle, whereas aortic arch continues. This is an important anatomic landmark. Often, surgeons use an oblique planning which passes from the upper limit of the ascending aorta to the proximal point of the brachiocephalic trunk origin. This landmark is useful in surgery, whereas it is not relevant to anatomy.

Louis angle also indicates the upper edge level of the pericardial sac. Thus, it turns out that the ascending aorta is the intrapericardial portion of the aorta in surgery too and that the pericardial sac may serve as effective anatomic landmark for the separation of the ascending aorta from the aortic arch.

Other authors consider the ascending aorta as a portion of the aorta from the bulb-tubular junction to the origin of the brachiocephalic trunk. There is the opinion that the ascending aorta is a vessel segment which passes from the ventriculo-aortic junction to the first branch of the aortic arch.

From the above explained, we may conclude that the used terms are not well-defined. The divergence of views in cases where authors do not indicate their option, can lead to misperception of that information.

This research paper uses the term of „ascending aorta" as part of the aorta from the aortic valve to the emergence of the brachiocephalic trunk, which, in turn, consists of two segments: the bulb and the tubular portion. The aortic arch is the segment of the aorta passing from the base of the first branch to the aortic isthmus, while the descending thoracic aorta – from the isthmus to the diaphragm, the abdominal aorta – under the diaphragm.

Some formations, such as subepicardic fat bodies, are very variable, and have from 13 to 15 names per each, but none of them fully reflects the location, shape and their function (tab. 4). In other cases, one and the same term is applied to different structures, e.g., "anterior fat body"- placed between the aorta and pulmonary trunk [35-38], for the one placed on the ventral side of the atria [39] between the aorta and right pulmonary vein.

In order to avoid confusion in terminology and prevent misperception of the information by the readers, I have used and recommended a term which does not lead to confusion of concepts and structures. As it is in case of multiple subepicardic adipose bodies. Thus, for the adipose collection of the ascending aorta which comes in contact with the edge of auricle of the right atrium, instead of various terms used to define the very structure: "semilunar fold, ridge, vincula, anterior fat body of the AA, periaortic fat body, transverse aortic fold, the ascending aortic fold" and others. As none of the names mentioned fully reflects the location or shape of the anatomical entity of a particular importance at present, we suggest to call it "Rindfleisch' fat pad" (RFB), showing a particular respect to the morphologist, who in 1884, was first to present the adipose subepicardic structure associated with the ascending aorta.

While physiologists are clarifying if intramural structures of the ascending aorta similar to the carotid corpuscle are ganglia, paraganglia or endocrine gland, chromaffin or non-chromaffin and which system they are related to (sympathetic or parasympathetic) we used such neutral terms as corpuscle or glomus.

Conclusions

1. Fat body of the ascending aorta is variable in form, location and individual size. It represents a formation of physiological importance, includes many glomus-type structures and often – lymph collector from the sinus node area. Obtained knowledge can be implemented in selecting a mini-access in surgery on this zone of the aorta.
2. The variation of the syntopic relationships between the arch of the aorta and left vagus and recurrent nerves is much more diverse than it is expected, a fact which should be taken into account while performing surgical interventions on the superior mediastinum.
3. Currently, when surgical maneuvers on the aorta have become routine, updating of terminology of aortic morphology has become an urgent necessity.

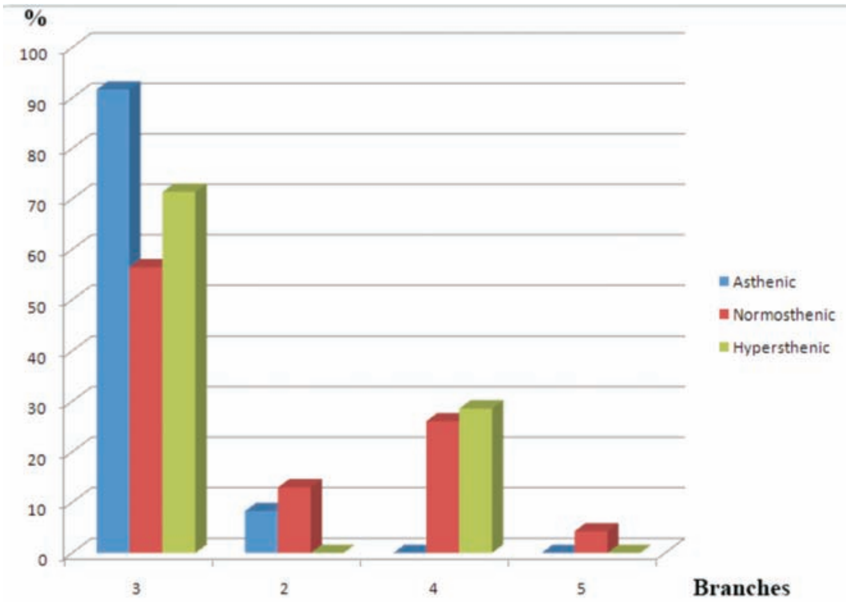

Fig. 7. Frequency of different branching patterns of the aortic arch.

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