CARRENT ISSUES OF THE AORTIC FUNCTIONAL MORPHOLOGY

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АКТУАЛЬНІ ПИТАННЯ ФУНКЦІОНАЛЬНОЇ МОРФОЛОГІЇ АОРТИ

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РЕЗЮМЕ

Стаття містить огляд даних, наявних в літературі, про локалізацію і морфології судинного і лімфатичного русла, рефлексогенних зон аорти і результати власного макроскопічного, мезоскопічного і мікроскопічного дослідження доповнює ці аспекти. Вперше описані регіональні клінічно значущі особливості кровопостачання і лімфатичного дренажу аорти. Погоджуючись з даними інших авторів про локалізацію рефлексогенної зони в дузі аорти, автор наводить відомості про наявність аналогічної зони в адвентиції висхідної аорти. Морфологічно обгрунтовуються причини ряду постоперацийних ускладнень у кардіохірургії та шляхи їх попередження.

АКТУАЛЬНЫЕ ВОПРОСЫ ФУНКЦИОНАЛЬНОЙ МОРФОЛОГИИ АОРТЫ

Т. Хачина

РЕЗЮМЕ

Статья содержит обзор данных имеющихся в литературе о локализации и морфологии сосудистого и лимфатического русла, рефлексогенных зон аорты и результаты собственного макроскопического, мезоскопического и микроскопического исследования дополняющего эти аспекты. Впервые описаны региональные клинически значимые особенности кровоснабжения и лимфатического дренажа аорты. Соглашаясь с данными других авторов о локализации рефлексогенной зоны в дуге аорты, автор приводит сведения о наличии аналогичной зоны в адвентиции восходящей аорты. Морфологически обосновываются причины ряда постоперационных осложнений в кардиохирургии и пути их предупреждения.

Keywords: aorta, fat pad, vasa vasorum, paraganglion, reflexogenic zone, atrial fibrillation.

The aorta is the blood vessel of the human body that was studied from the point of view of its macroscopic and microscopic structure, ontogenesis, its sources of innervation and vascularization and a lot works were written on this subject. It seemed to us that everything is known about the aorta. Articles on the morphology of the aorta have been published rare for the last two decades. At the same time the number of articles published by clinicians, especially cardiosurgery from many countries who treat the diseases of the heart and aorta deal with the problem of the lack of morphological evidence that account for a number of postoperative complications and the ways to prevent them. The other problem that runs through a lot of recent articles is an insufficient presentation of interaction of the heart and aorta lymphatic and nervous apparatuses. When the incidence of morbidity and mortality caused by cardiovascular diseases increases all over the world and when surgical operations on the aorta and heart have become routine, an urgent need for a detailed study of vasa vasorum and nervi vasorum of the aorta as well as its lymphatic apparatus has arisen.

A notable progress in thoracic surgery only emphasizes the need for research into the intraorganic and paravasal apparatus of the aorta. Clinicians state numerous cases of postoperative blood oozing and explain it by the administration of heparin to prevent thrombosis in this period. However, it is not possible to give any explanation in cases of the development of a profuse bleeding that require resternotomy after operations when the aorta is the access point.

Atrial fibrillation is another more frequent postoperative complication in such surgeries. At present the preoperative and postoperative administration of antiarrhythmic medicines to all patients in need of surgery on the heart does not contribute to the decrease of the incidence of this complication. Frequent site effects of this treatment are known.

As the ascending aorta is involved in heart operations (it is the access poin, the point of connection the arterial magistral of the heart-assist device, the point of hemostat imposition and introduction of the needle to remove a residual air) there is a need to study the interdependence of their intraorganic lymphatic and nervous apparatuses.

It is known that 20–40% of patients after the heart surgery with the involvement of the aorta suffer from irregular heartbeat, especially atrial fibrillation, 7–20% of all postoperative patients die. In spite of all effort of the specialists in reparative surgery of the aorta to prevent and to stop the development of aortic aneurism, including dissecting one, no evident and stable results are noted.

To achieve success in the treatment and prevention of such cases is possible only after having obtained

all data on the vascular nervous apparatus, way of the lymphatic drainage and morphological reasons.

Taking into consideration the inefficiency of therapeutic methods to treat a number of aortic diseases, the increasing incidence of surgeries in them to save patients lives and impossibility to operate on the heart without a number of manipulations on the aorta, especially on its ascending part, the lack of morphological and physiological reasons of developing complications, the need to analyze the data of previous studies again is evident. In our opinion, the main subjects are regional specific features of vascularization, ways of lymph drainage of the heart and aorta, as well as localization of vascular reflexogenic zones.

Literature review. It should be noted that the same structures are named differently by authors when the morphology of the aorta is described, that is the terminology is imperfect. So, the bulb of aorta is named dilated first part of the *aorta* containing the *aortic* semilunar valve and the *aortic* sinuses, in some works (i.e. the American Heritage ® Medical Dictionary by Houghton Mifflin, 2010), it is distal extension of the ascending aorta before the arch, in other works (Ruggero De Paulis, 2006, 2009). The last decade is marked by an increasing interest in fat pads of the heart and aorta that contain, in the opinion of some authors, nerve conductors important for the heart activity. One group of authors describe fat pads of the heart, the other group describe the aortic ones [13–18], and the third group describe the epicardial fat pads [34, 35], though they all are located under epicardium. This confusion in terminology inhibits the fast implementation of morphological data into practice.

The description of fat pads on the ascending aorta is a concrete example. Subepicardial pad of the aorta were first described by German pathologist Rindfleisch in 1884. In his opinion this structure is necessary during the heart systole and it stimulates strengthening of the aortic wall. Taking into account the clinical significance of this accumulation of fat and the fact that it has not been studied by clinicians for more than a century, we present the chronology of published articles on the issue. Gross (1921) implies the presence of relation between the state of the blood vessel in this zone and coronary insufficiency. Davis (1927), Smetana (1930), Robertson (1930) describe anastomoses of the right and left coronary arteries in this region. Parke and Michels (1966) add data on the sources of blood supply of the ascending aorta and its fold. They consider subepicardial fat pad of the ascending aorta located on the line of the contact of the edge of the right atrium and the aorta to a shock-absorption structure. All authors state the presence of the ascending aorta fat pad at the level where aneurisms often develop, though the conclusions are drawn on the basis of a limited number of cases. As it was the time of experimental coronary artery

bypass grafting, they attempted to interpret functional significance of this fat collection.

At the end of the XX century the interest of cardiosurgeons in this region increased considerably. In 1991 Israeli researchers G. Falkowsky, I. Dzigivker, D. Bitran [6] and in 1999 F. Unger and W. G. Rainer raised the issue of terminology of this anatomical structure [31, 32]. Lebona (1993) describes its macroscopic variants and later this author describes the presence of the paraganglion in the aortic fat fold and its microstructure [13, 14]. However, no other works on the subjects were published and this fact can be explained by smoothing of this fat pad in embalming of dead bodies. On the other hand, the conclusion suggests a weak interaction between pathologists and clinicians in doing research.

Nowadays when open heart and aorta surgery has become an everyday reality all over the world and coronary artery bypass grafting has become a frequent and effective technique to save lives of millions of people. Clinicians are sounding the alarm as for a high incidence of such postoperative heart complications as atrial fibrillation and bleeding that require resternotomy and a detailed study of the ascending aorta has become an urgent need. Thus, the first decade of the XXI century has been marked by a new interest in the ascending aorta morphology and its significance.

British researchers J. J. Morrison, M. Gospodini, C. Campanella (2003) point out at the ascending aorta fat folds as a surgically significant structure [23]. In a number of articles this morphological structure is called enigma [22,32]. In 2004–2005 the journal «Clinical Anatomy» expands the discussion concerning the functional significance and terminology of the aortic fat pad with the participation of Lindsay, C. H. John [15], J. J. Morrison with coauthors [22], F. Unger [32, 33]. So, the transversal crest, aortic crest, aortic fat pad, ascending fold, transversal fold, semilunar fold, fat ring of the aorta, periaortic fat pad, Rindfleisch fat fold represent a list of names of the same ascending aorta fat pad that, according to new data, is of great significance in monitoring the heart activity. Recently a lot of articles have verified the fact that on lesion of fat pad on the anterior surface of the ascending aorta the risk of atrial fibrillation and fatal outcome increases [1, 4, 5, 19, 36]. However, there are some fat pads on the ascending aorta and, if illustrative data are not available, it is very difficult to understand which of them is meant and, consequently, it is not possible to implement accumulated theoretical data into practice.

So, according to Zev Davis (2000), in case the fat pad remains intact atrial fibrillation occurs in 7% of patients and in case of its destruction — 27% [36]. The majority of researches explain it by intraoperative destruction of nerve conductors that provide heart innervation at the level of the ascending aorta and, consequently, by the loss of vagus effect on the sinus

node. Only Lupinsky [18] in his works suggests the idea of the impairment of the ways of heart lymph drainage as the factor that leads to this complication.

Up to now the issue the aorta lymphatic net has not drawn much attention of pathologists and clinicians. Data on the intraparietal lymphatic net obtained three-four decades ago and based on the injection methods are contradictory and they do not depict its regional specific features. In some articles the lymphatic nets of the aortic wall are described, other articles affirm their presence only in the paraaortic cellular tissue. We have not managed to find any data on lymph drainage from the heart and aorta based on modern methods of investigation.

Data on the innervation of the aorta are constantly supplemented [30, 31]. All articles on the reflexogenic zones of blood vessels state their presence in the region of the carotid sinus and aortic arch [11]. V. N. Chernigovsky (1944) asserts in his articles that angioreceptors are present throughout the vascular system, but their accumulations are located on the wall of the aorta, pulmonary circulation vessels and in the carotid sinus. In many articles particularly sensitive areas of the arch are not specified, that is the whole area of the aorta is considered as the area of marked hemo- and baroreception. In some articles the area of the arch in the point of origin of the subclavian artery is specified, in other articles — the amyous areas on the anterior surface of the arch (T. A. Grigorieva, 1948, 1954) near the point of arterial ligament attachment, at the base of the brachiocephalic trunk and bronchial branches.

The opinion on the depth of location of sensitive nerve endings in the aortic wall differ [2, 3, 9, 12, 16, 20, 29]. So, A. Abraham (1950, 1953, 1961, 1963) notes the absence of baroreceptors in the aotric media. In the same years A. V. Babaskin (1952, 1953) and later B. M. Smolkina (1967) describe the single nerve plexus of the middle layer of the aortic wall. The majority of authors describe baroreceptors in the form of compact and diffuse clusters and terminal reticulated plates. I. Slepkov (1952, 1953) described in the articles not only the above mentioned forms but encapsulated nerve endings of Krause bulb type as well he did not highlight the issue of the existence of certain reflexogenic zones in the aortic wall. The availability of this type of receptors in the aortic wall is confirmed in the works of Heisman (1966). The opinions of localization of hemoreceptors are also diverse. The studies of pathologists Penitschka (1931), Palme (1834), Nonidez (1935, 1937) and Boyd (1937) showed the presence of cells identical to the carotid glomus in the aortic arch. Penitschka describes paraganglion aorticum and later — paraganglion aorticum supracardiale between the aorta and the pulmonary trunk. Iulius H. Comroe (1939) proved in experiments on animals the presence of hemoreceptors

on the ascending aorta, pulmonary trunk and proximal arch area adjacent to it and their blood supply through the branches of the aorta. The author did not reveal any hemoreceptors in adult animals and pointed out an individual variability these receptor structures. I. H. Comroe and Addison (1938) proved the presence of glomus cells accumulations in the adventitia of small aortic branches within 1 mm of their origin. The interest of pathologists in reflexogenic areas of the heart and aorta in the 50–60s of the XX century is clear as it was the period of experimental and later clinical heart transplant. N. M. Bykov (1951) described the nodule 1–2 mm in diameter located between the aortic arch and the point of bifurcation of the pulmonary trunk. Small branches of the pulmonary trunk supply the nodule with blood and those of the aorta do not participate in its blood supply. Later E. B. Heisman (1966) presented opposed data on vascularization of the aortic reflexogenic area. Speaking about hemoreception Heimans and Neil (1958) point out aortic paraganglia. According to William J. Crause paraganglia are located in some vascular areas: the point of branching off of the left subclavian artery and the corner between the right common carotid artery and the right subclavian artery. Christopher Edwards and Donald Heath (1960) described multiple glomus structures around the heart and large blood vessels, one of which, according to their data, is constant. It is located on the dorsal surface of the point of bifurcation of the pulmonary trunk and is supplied with blood through its branches. The descriptions of this glomus by other authors are very contradictory. For instance, Becker (1966) considers it to be one of the coronary glomuses and it is supplied through the branches of the coronary artery. E. W. Kienecker and H. Knoche (1978) using fluorescent method for the determination of catecholamines demonstrated the subendothelial location of the terminal adrenoceptive endings in rabbits, their limited number in relation coronary glomus cells of type I. These authors affirm that sympathetic innervation of the ascending aorta is weaker in comparison with the pulmonary trunk and its own vasa vasorum.

From the 80s to the beginning of this century the interest of researches in baro- and hemoreceptors decreased, but successes in cardiosurgery in recent years and increased requests for morphological data on the heart and aorta dictate the need for further research in this field.

Despite the great number of works on the aorta glomus structures, there is no consensus on their location so far. According to The American Heritage and Stedman's Medical Dictionary (2002) these small-sized attach to the aortic arch being bilateral in relation to its small branches. In one of the articles of Piskuric et al. (2011) the presence of hemoreceptors of the aortic arch was proved on the basis of immunofluorescent

investigation of aortic glomuses in ducks. Jonathan Balcombel et al. (2011) developed a classification of the aortic glomuses:

1) coronary, located at the base of the arteries of the same name;

2) pulmonary, located between the aortic arch and pulmonary trunk;

3) subclavian, in the angle formed by the subclavian artery and the aortic arch.

Results of the study and discussion. Numerous studies of subjects at the macroscopic, mesoscopic and microscopic levels and a wide range of used methods, including immunological investigations, expand knowledge of the morphology of the ascending aorta and its fat pads in particular.

According to our observations on the ascending aorta there are several subepicardial fat pads:

1) anterior, located in the anterior aortopulmonary groove;

2) posterior, placed in the posterior aortopulmonary groove;

3) coronary, at the base of both coronary arteries;

4) transversal, at the level of the contact of the edge of the right atrium with the aorta.

As their form, the degree of manifestation, localization and functional significance are diverse and none of the terms used expresses the essence, shape, and location, they will be called anterior, posterior, coronary fat pads. That transversal will be termed as Rindfleisch fat pad ((RFP), as a tribute to the first researcher of fat fold of ascending aorta. Special interest in the latter is due to its clinical significance.

Proximally to the pad the introduction of aortic cannula and clamping are carried out during heart surgery. At the level of the pad antegrade cardioplegia and catheterization are done to perform cardiopulmonary bypass and proximal coronary bypass. Often the pad is removed during surgery to facilitate access and to simplify medical manipulations on the ascending aorta. All authors of articles on RFP state its location on the anterior surface of ascending aorta. It is possible to come to such a conclusion on the basis of a limited number of observations, but having studied over 400 subjects we made sure that it is true in 79% of cases. Thus, in some cases RFP occupies the anterior surface of ascending aorta, in other — the anterior and right ones and in the third group of cases it comprises and a part of its posterior surface. According to our observations in 21% of cases this fat pad is not market on the anterior surface, but it is well developed only on its right or posterior semicircle (Fig. 1, p.8). The fat pad can be in the form of a strip (p.1); cylinder (p.2); crest (p.3; fold (p.4); pad (p.5 and 6); ramified and it can also be of a combined form: strip-pad, cylinder-pad, etc.

The other authors' typical inexactitude in the description of RFP is the statement of its location at the base of the aorta. The base of the aorta is covered with the pulmonary trunk and the atrium, but RFP is located on the base of the visible part of
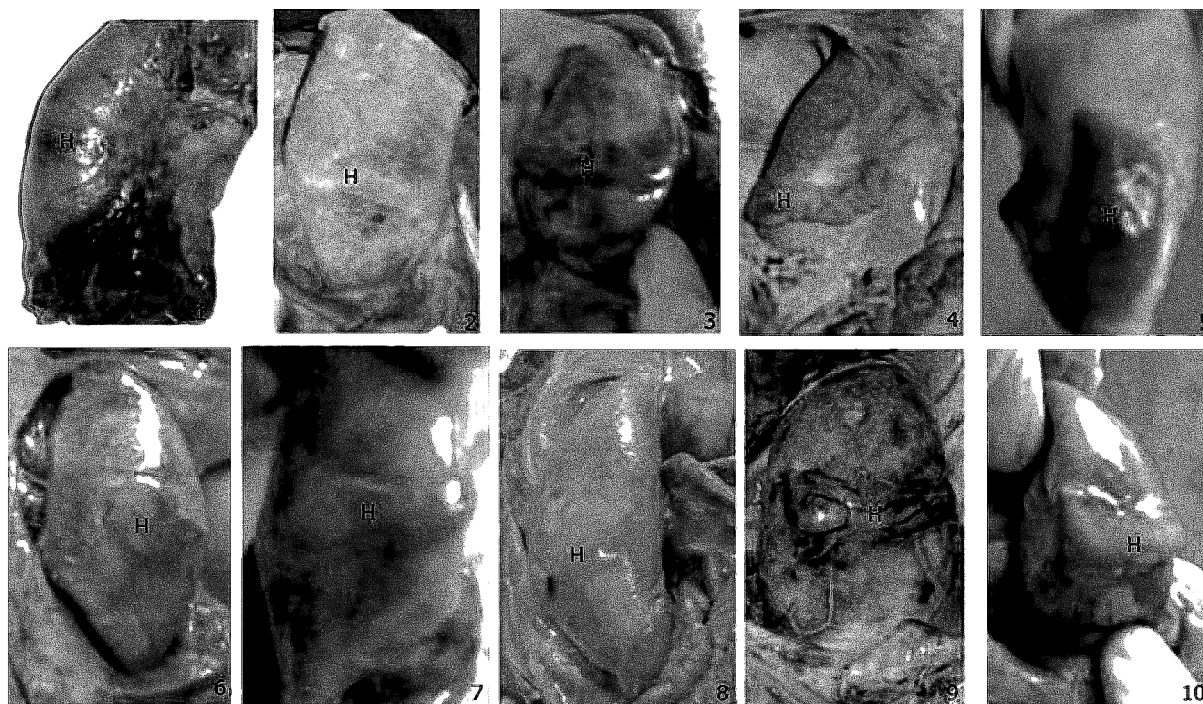

Fig.1. Variants of the Rindfleisch fat pad (H). 1- strip; 2- cylinder; 3- crest; 4- fold; 5- oval; 6- spherical; 7- branched; 8- fat pad on the posterior surface of the aorta; 9,10- combined
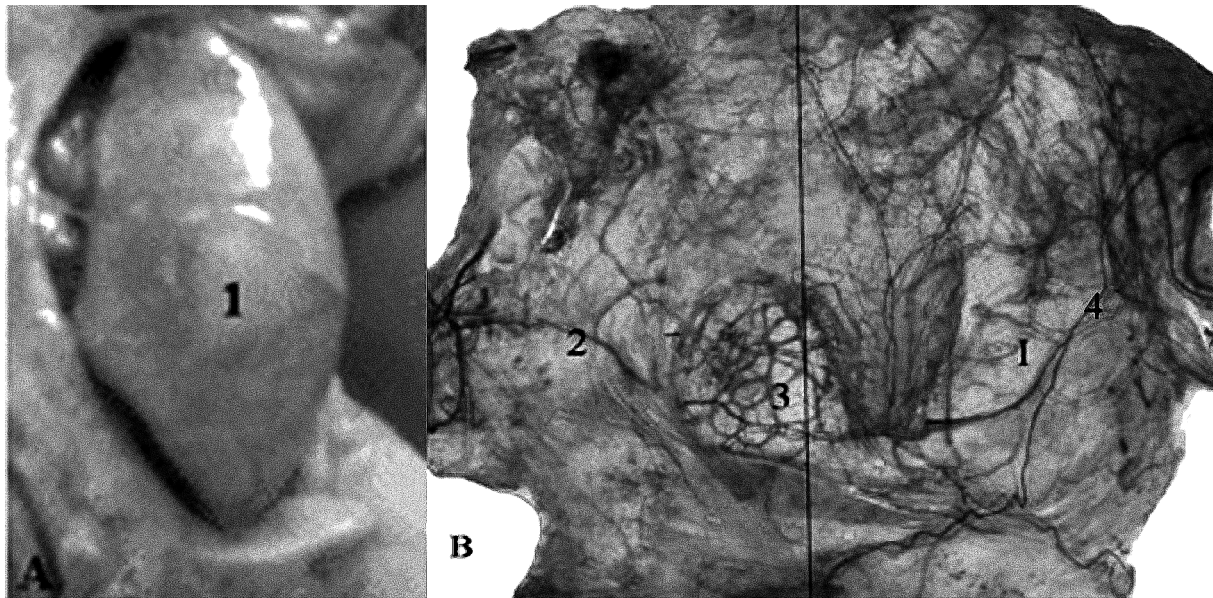
Fig.2. A – Rindfleisch spherical fat pad; B – external layer of the ascending aorta wall coloured by reagent Schiif. 1- the anterior semicircle of the aorta; 2- the posterior semicircle of the aorta; 3- the net of anastomoses; 4- vasa vasorum internae

the ascending aorta. According to our data, the level of location of this structure is variable: frequently it is placed between the proximal and middle thirds of the ascending aorta; in 30% of cases — between its inferior 2/5 and superior 3/5; in 12% of cases — in its midpoint. And, finally, the lowest level is above the proximal 1/6 of the AA. The correspondence of RFP location and the contact point of the edge of the right atrium and aorta remains constant. The degree of pad accumulation does not correspond to the general level of fat storage in the body. In some cases we observed underdeveloped fat pads in the III-rd grade of obesity, and vice versa, a marked fat pad in cachexia. It will be more exactly to note the relationship between RFP and the development of the right atrium. The following data support the our point of view. Fat pads are not infrequently more marked in the prenatal period than in the postnatal one (atria are known to be developed relatively better in the fetuses). In case of right atrium hypertrophy fat storage is more considerable.

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 (Fig.2). We developed recommendations on the type of fat pad in operations that provide direct or indirect manipulation of the AA. The recommendations contribute to an individual approach to select the location of place of incision. This, in its turn, allows to prevent drug-free the most frequent complications in cardiosurgery, such as atrial fibrillation and bleeding. Medicines used to treat these complications are not very effective and they often produce side effects. Such treatment is administrated to all patients without exception, though there is risk of

complications no more than 40% of them. In the best-known guides for surgeons, books for medical students and postgraduate students the phenomenon of fat pads of the ascending aorta is not mentioned.

A number of regional specific features of the blood supply of the AA was revealed by means of injection of colored gelatin into the AA through the brachiocephalic trunk. The sources of the blood supply of the AA can be divided into two groups: ascending and descending. According to our data the branches of both coronary arteries refer to the first group, though other authors affirm the participation only of one of the two. The branches of the bronchial arteries and artery accompanying the vagus branch to the heart are related to the second group. This subject is described in articles of many researches [7, 8, 24, 25, 26, 27, 28]. All above mentioned vessels are located along the axis of the ascending aorta. Against this background we should note the fact that at the level of RFP all large blood vessels and nerve trunks are transverse to the axis of aorta. Other vessels with transversal direction that are branches of the coronary arteries are revealed at the base of the aorta on the line of fixation of the leaflets of the aortic semilunar valve.

Transverse arteries of RFP, in contrast to other vasa vasorum aortae, are the internal ones, i.e. they do not begin outside the wall of aorta, they branch off and ramify in the adventitia of the subepicardial AA area. Their origin is on the concave side of the ascending aorta, normally 1–1,5 cm above RFP and their number ranges from 1 to 7. As a rule, one or two of them are directed obliquely: downward and to the right and they participate in the formation of an abundant vascular net of the given fat pad anastomosing with other vascular sources (Fig.3).
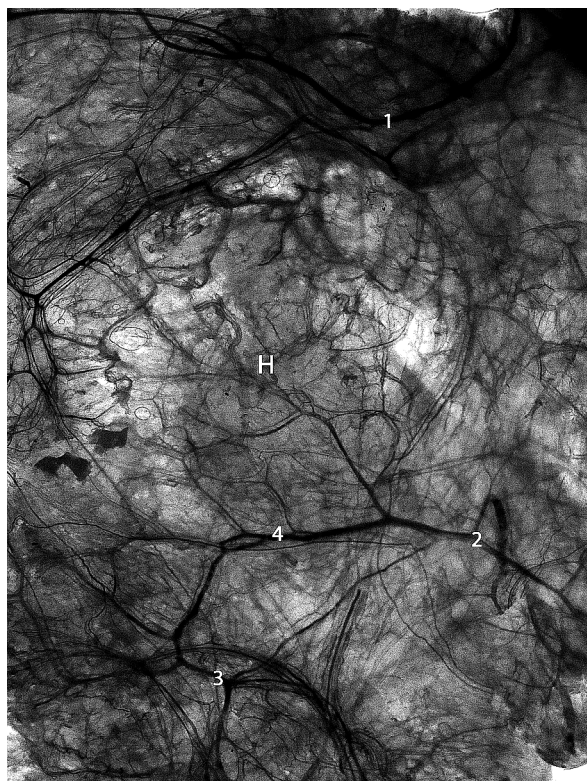
Fig.3. Mesoscopic aspect of vascular sources of the Rindfleisch fat pad. 1- vasa vasorum internae aortae; 2- branch of the left coronary artery; 3- branch of the right coronary artery; 4- anastomosis between both coronary arteries; H- anastomoses between descending and ascending sources of blood-supply

Fig 4. Cross-section of the paraganglion located in the Rindfleisch fat pad

Cases of profuse postoperative bleedings in this area are substantiated by a great abundance of blood vessels in comparison with other areas of the aorta on the whole, on one side, and by a high blood pressure in these vessels, on the other side. The presence of valve is a characteristic feature of the RFP veins. It is, apparently, an adaptation of vessels to complex hemodynamic conditions of the ascending aorta required to prevent reflux.

Paraganglia are an important component of RFP. There are a lot of data on the paraganglion of the abdominal aorta, that is known as Zuckerkandl organ. In a number of articles on paraganglia located in the connective tissue between the aorta and pulmonary trunk they are called upper and lower supracardial paraganglia. The first description of the microscopic structure of the paraganglion of the ascending aorta belongs to Lebona, a researcher from Republic of South Africa [14].

Our data show a striking similarity of the ascending aorta paraganglion and the glomus of the carotid reflexogenic area (Fig.4): the same two types of cells and an abundant vascular net. As a rule, the paraganglion is not single, it is penetrated by one of the branches of ascending aorta vasa vasorum internae
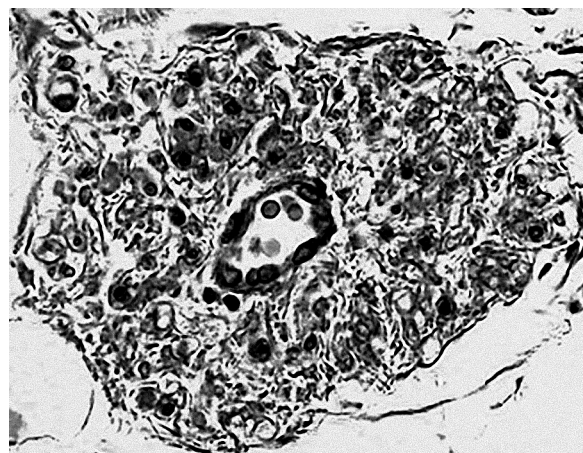
through the center. Moreover, there are small but numerous subepicardial accumulations of chromaffin cells. These facts suggest the presence of hemoreceptor area of the ascending aorta.

In RFP are numerous nerve trunks that contain intratrunkal neurons, free and incapsulated nerve endings with the functions of baroreception.

The trajectory of the intraparietal arterial vessels of the aorta differs in its different parts. Numerous vascular loops elongated a little along the axis of the aorta are formed in the adventitia of the convex surface of the arch. In the lower concave area of the arch there are small branches of the bronchial arteries ascending to the anterior and posterior semicircles of the aorta. The presence of segmental contralateral anastomoses is characteristic of the descending aorta and it should be taken into account in determination of an operative access in spondylectomy.

In availability of diverse regional specific features of blood supply of the aorta is obviously due to complexity of ontogenesis of the aorta (the availability of many sources of development) and the difference of hemodynamic conditions along the main arterial vessel of the human body. Thus, the bulb of the aorta, that derives from the arterial trunk, is supplied with blood through branches of the coronary arteries; the supply of the distal ascending aorta and a larger part of the aortic arch that originate from the aortic sac, is provided from the brachiocephalic trunk and vasa vasorum internae. The concave part of the arch, formed from the fourth aortic arch, is supplied from the branches of the bronchial and mediastinal arteries. The descending aorta originates from the dorsal aorta and it is supplied from the branches of intercostal and lumbar arteries.

The arterioles of adventitia of the ascending aorta acquire a sinusoidal trajectory with age that can be considered as a protective mechanism in excessive tension of the aortic wall during systole. This characteristic becomes more marked at the age over 50.

The venous net of all parts of the aortic wall is formed deeper than the location of the arteries. Venous adventitial plexus of AA is formed 1–1,5 cm proximal of the aortic arch. Drainage is carried out in two longitudinal veins (one is on the anterior surface and the other is on the posterior surface of the aorta) 140–150 μ in diameter with plenty of transverse anastomoses. These veins flow into the tributaries of ventricular veins of the heart located at the base of the aorta.

Intramural vessels are of great importance in the functioning of each organ, including the aorta. We studied the formation of the aortic blood stream. Isolated blood vessels in the paraaortic connective tissue were revealed in a 5-week embryo. In 1–1,5 week vessels in the adventitia of all divisions of the aorta develop. In the following weeks the intensity of vasa vasorum in the proximal part, i.e. on the ascending aorta, is higher. The development of vessels occurs later with distance from the heart. As a result, in 7–8 weeks there are 7–8 vessels in the AA adventitia, whereas in the abdominal part — only 3–4 vessels. This tendency continues within the whole intrauterine period. No vessels were revealed in the middle layer of the aortic wall in a 9-week embryo. Several blood vessels were revealed in the AA media in a 10-week embryo. Blood vessels are revealed in the thoracic aorta in a 17–25-week fetus. The regularity of a greater provision with vessels of the proximal areas of the aorta than of those distant from the heart is also observed in the middle layer. In the adventitia of a newborn there is a developed intramural vascular net of the aorta with the branches that grow into the outer layers of the aortic media. According to the data of researchers vasa vasorum of the aorta develops faster in the embryonic period and the period of growth (Clarke J.A, 1966; Gossl M., 2004). It should be noted that internal vasa vasorum of the AA can be seen with the naked eye under the epicardium of a 16-week embryo. The development of the RFP also occurs in the later stages in comparison with the other areas of the aorta. There are many issues of clinical medicine on the morphology of the aorta. Thus, the poorest vasculature is characteristic of two areas of the aorta adjacent to the aortic arch: the distal area of the ascending aorta and proximal area of the descending thoracic aorta. It should be noted that these are the areas where dissecting aneurisms of the aorta develop (M.E. De Bakey, 2000). Is it a coincidence or regularity?

Despite advances in the prevention of aortic atherosclerosis the problem of affection of this vessel remain s unsolved. Observation of more than 200 cases with the definition of the thoracoabdominal index of the aorta (diameter ratio of the proximal and distal areas of the descending aorta) showed that the severity of pathological process depends directly on its index, i.e. a sharp narrowing of the aorta develops hemodynamic conditions contributing to a faster development of disease than a smooth one.

What factors does the shape of the largest blood vessel depend on? Is it possible to influence the morphogenesis of the aorta?

Data on the lymphatic apparatus of the aorta are incomplete and they are not systemized. Comparative regional data are not available. There are no reliable sources that confirm or refute the information obtained by researches in the last century.

On the basis of our study on the mesoscopic level with the use of coloring reagent Schiff the trajectory of the large lymphatic collector providing drainage from the sinus area was described in addition to revealing of lymphatic vessels in the aortic adventitia. In our opinion, its lesion in surgery causes atrial fibrillation. The fact that this complication develops in 2–3 days after the surgery and not immediately is the proof of that. Consequently, lymphostasis leads to this dangerous complication. Here we can answer the question why atrial fibrillation develops not in all patients in the impairment of fat pad integrity. There are two reasons that:

1) individual specific characteristics of drainage (only in 60% of persons the lymph outflow from the right atrium occurs on a large collector, in the rest — on the net of lymphatic vessels, which injury does not lead to stasis in the sinus area as the lymph passes through collaterals);

2) choice of the site of incision of the ascending aorta in above mentioned surgical manipulations (injury of the lymph collector, which trajectory was described by us in other articles, should be avoided).

Our data on the presence of a large drainage trunk of the right atrium on the anterior surface of the ascending aorta confirm the data in the previously published work of Golab [10]. Along with it, we were the first to reveal the presence of subepicardial lymphatic nodules that are regional for the sinus node area.

As for the receptor apparatus of the aorta, it is very diverse, along with nerve endings in the form of tendril, loose or dense bushes and incapsulated ones as well. The latter ones were noted in RFP in all cases.

In our opinion, regularity of the presence of these pressoreceptors in this area of the aorta is not random. Multiple nerve nodules were revealed on the anterior surface of the AA attached to the pulmonary trunk. Not a few of nerve nodules are located on the posterior surface of the aorta close to the pulmonary trunk, but their number and size are smaller.

While studying all the areas of the thoracic portion of the aorta we have not managed to reveal such combination of specific characteristics of vascular, lymphatic and nervous apparatus as in the area of RFP. These observations suggest this anatomical structure to be a reflexogenic area of the aorta.

Thus, a sparing approach to RFP during surgery is one of the conditions for success.

CONCLUSIONS

Separate parts of the vascular bloodstream and lymphatic apparatus of the aorta not known before were revealed for the first time.

Our data, supplementing information on the nervous apparatus, vasa vasorum and the aortic lymph drainage ways, allowed to reveal reasons of some postoperative complications and ways to prevent them.

New findings on the nervous apparatus of the aorta promote better understanding of the mechanisms of self-regulation of the cardiovascular system.

Obtained knowledge of regional specific characteristics of the aorta can be implemented in selecting a mini-access in surgery on different areas of the aorta.

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