MORPHOMETRIC STUDY OF AORTIC ARCH

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Keywords: *aortic arch branches, morphometria*

Abstract: *Morphometrics involves determining some well-defined metrics, positioning toward clear landmarks and removal of the items that might influence the correct interpretation of these parameters. Morphometrics is an important object of study in the evaluation of living organisms. Morphometrics' object of study is to set certain parameters (length, diameter, angles etc.) in precise limits.*

Cuvinte cheie: *arc aortic, ramuri, morfometrie*

Rezumat: *Morfometria implică determinarea unor măsurători bine definite, poziţionarea faţă de repere clare şi eliminarea elementelor care ar putea influenţa o interpretare corectă a acestor parametrii. Morfometria reprezintă un obiect de studiu important în evaluarea formei organismelor vii. Obiectul morfometriei este de a stabili în limite precise anumiţi parametrii (lungime, diametru, unghiuri etc.)*

INTRODUCTION

Morphometrics represents an important factual study in the evaluation of living organisms. The object of morphometrics is to set certain parameters (length, diameter, angles, etc.) precise limits, which are very useful in describing and comparing the characteristics of a particular object/organ and the implications of the change in form over function. It is frequently used in determining changes in the form of living organisms, alongside ontogenesis.

Morphometrics contributes with quantitative elements to the achievement of the anatomical descriptions. It allows for the description of complex forms in a rigorous manner and enables evaluation, numerical and statistical reports useful in medicine. Thus, the interpretation of anatomical shape in the form of numbers allows for an objective interpretation.

Morphometrics involves determining some well-defined metrics, positioning toward clear landmarks and the removal of items that might influence the correct interpretation of these parameters.

Morphometrics, as part of anatomy, had begun to be used long ago, as the importance of statistical data processing grew. Until recently, the anatomy had related to the direct discovery of constituents of the human body and their description in ways that were more or less subjective.

The combination of direct observation, together with thorough descriptions accompanied by numeric values that provide a high degree of accuracy have determined an approach to anatomical variations and anomalies, more accurate and more useful to the medical practice.

PURPOSE

The idea for this study had started from the observation of how the anatomical depictions of the aortic arch and its branches, the brachiocephalyc trunk and the left common carotid artery were represented at a variable distance from each other. The reason behind all these is purely didactic, allowing the visualization of the aortic arch behind the trachea and its branches which have relations with its anterior face. In the classical anatomic descriptions, few authors refer to this aspect because, in practice, the origin of the left common carotid artery and its ratios are much closer to the arterial brachiocephalic trunk. Thus, came up the idea to determine, in a precise manner, the values of the diameters, distances and angles of these extremely important anatomical landmarks.

Vascular surgery is the one that has brought a great contribution in the study of aortic arch and its branches. Surgeons have described variations and anomalies encountered in medical practice being aware of the importance of knowing how the aortic arch and its branches may be subject to major variations or not, with a direct effect on the practical interventions.

Medical imaging finds and completes the whole picture of the variability of anatomical dissection, and direct observation of anatomical elements can characterize the objective image.

In the local medical literature, Pop D. Popa is an author presenting morphometric data showing the aortic arch. We have not yet heard about studies that treat this subject extensively.

For this reason, I wish to carry out a morphometric study on one of the most important vascular anatomical elements not subjecting to the general rules of division and morphometry, as it was shown in the first part of the paper.

Studies conducted by foreign researchers are morphometric measurements carried directly on the anatomical elements and anatomical measurements and determinations through the latest imaging.

The aorta is not a static organ. Due to its structural features, it is permitted to adapt its diameter to the changes in blood flow or permanent increased TA. This is because the determinations made in this paper are not made in real time, but it also represents data obtained from the study on the necroptic materials that should not be taken over and interpreted in other conditions.

METHODS

The current study is represented by the morphometry of the aortic arch. It was developed within the Department of

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Forensic Medicine of the County Emergency Clinical Hospital Sibiu; the studied parts were obtained from fresh cadavers because we wanted to achieve results which would not be affected by the conservation and preparation of organs and bodies. There were used a number of 75 corpses, of which 46 males and 29 females, between the ages of 18 and 74. In addition to these, we have studied the pieces coming from the other six corpses, five males and one female, which were found with variations in the branches of the aortic arch that were not included in our morphometric study.

Dissection was done in a particular way, anatomical dissection having been adapted to internal exam timings of medico-legal autopsy, thus having been finished all the steps.

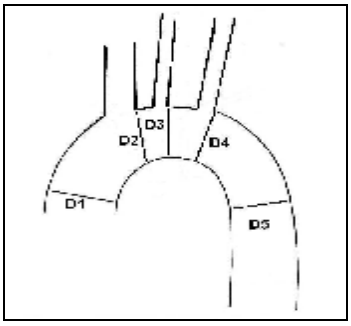
The determination of measurements was done as shortly as possible from harvest to avoid any structural changes at the level of the piece which would later influence, in one way or another, the result of the study.

We have harvested parts from deceased persons, dead for reasons which have not influenced the anatomical wholeness of the aortic arch (for example, we have not used parts from deceased people due to traffic accidents or trauma).

The following aspects have been investigated regarding the internal morphology of the aortic arch:(1)

- D1-inner diameter of the aortic arch, above the upper edge of the pericardial sac (considered the boundary between the ascending aorta and aortic arch);
- D2-inner diameter of the aortic arch, after the emergence of the arterial brachiocephalic trunk;
- D3-the inner diameter of the aortic arch, after the emergence of common carotid artery left;
- D4-inner diameter of the aortic arch after the emergence of the left subclaviculary artery •D5-inner diameter of the aortic arch in the isthmus.

Figure no. 1. Measurements determined at the level of the aortic arch



Detachment of aortic arch was done in long axis, the line section crossing the area of origin of branches of the aortic arch. All data obtained from measurements were analyzed separately for the two genders and then compared (figure no. 2).

Figure no. 2. Measurements methods

RESULTS

1. Aortic arch

In relation to the diameter of the ascending aorta, the minimum value determined for the parts collected from male cadavers, was 20 mm, while the maximum measurement was 31 mm.

The diameters measured after the emergence of the aortic arch branches will decrease gradually up to the isthmus to register the smallest diameter of the arc. This pattern of values was present at all the pieces. The smallest value from the isthmus to the pieces collected from men was 14 mm.

The calculation of average values of the specific diameters have showed values corresponding to the literature cited. For the ascending aorta, the average was 26.1 mm, the reference values being between 25-30 mm, while the diameter of the isthmus for the average value was 20.47 mm, the reference values being between 20-25 mm.

For the body parts harvested from female corpses, the values recorded were lower than those from male cadavers. The smallest value of ascending aortic diameter was 15 mm, while the largest had measured 26 mm. The average value was 21.68 mm (table no. 1).

Table no. 1. The diameters of the aortic arch with parts harvested from female cadavers, the lowest values - red, the highest values recorded – blue

No. piece	D1	D2	D3	D4	D5
1	23	19	18	18	20
2	15	13	12	9	12
3	17	14	12	12	12
4	20	17	16	16	14
5	21	17	17	14	16
6	25	22	20	20	18
7	23	20	18	18	18
8	22	22	20	19	17
9	20	20	18	18	15
10	15	14	12	12	12
11	26	21	19	19	19
12	24	18	16	15	20
13	20	17	14	14	13
14	20	17	15	15	14
15	22	19	20	18	18
16	24	22	22	20	19
17	19	19	17	17	17
18	21	21	19	17	17
19	18	16	15	15	15
20	22	19	19	18	17
21	25	24	22	21	19
22	21	19	19	18	18
23	24	20	19	19	18

24	23	21	20	20	19
25	25	22	22	21	21
26	22	19	17	17	17
27	23	21	21	21	19
28	23	21	21	19	18
29	26	24	23	23	23

At the isthmus, the lowest value was 12 mm in diameter, and the largest value of 23 mm. The average diameter at this level was 17.06 mm.

Both environments are smaller compared to the literature taken as a point of reference

Compared to the two genders, registered average values were higher for males. All values, at both males and females, will decrease as they emerge from the aortic arch.

2. Atheroma Plaques

Atherosclerosis represents a vast pathology, of major importance, causing the obstruction of the lumen of vessels throughout the body leading to ischemia distal to the obstruction point, or even infarcts.

Determinism of this disease is a complex and intricate one, incriminating both genetic and environmental factors.

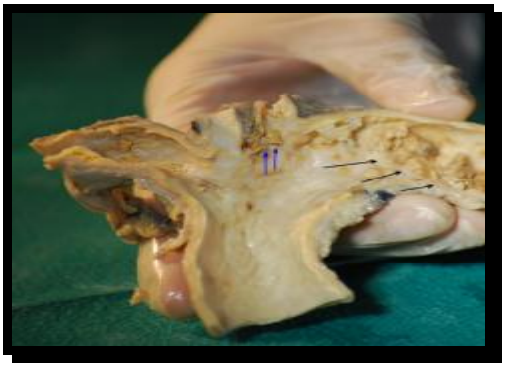
Spatial distribution in relation to the development of atheromatous lesions along the vascular system varies according to the individual. An important role is assigned to the hemodynamic factors that act upon the walls of vessels being widely accepted that the most common places for the emergence of such lesions are areas where vascular geometry is changed, at confluence and bending zones of the vessels.(1)

Although an important risk factor is vascular geometry, which influences hemodynamic parameters, it is difficult to correlate with the other risk factors or determinants. Of the parts examined, 28 were discovered with atheromatous lesions at various levels. Only 6 of these have originated from female cadavers (table no. 2).

Table no. 2. Places where atheromatous lesions were present

	Aorta	
	Ascending aorta	Aortic isthmus
Women	1	2
Men	4	5

Figure no. 3. Aortic arch's internal layout, black arrows indicate the atheroma plates at the level of the aortic isthmus, and descending aorta, the blue arrows indicate atheroma plates at the left subclavian artery



Studies on this phenomenon are just at their beginning. If risk factors and the determinants could be established, what brings about the atherosclerotic plaques at some level remains to be demonstrated. Today, computer models that recreate the geometry of the aortic arch and hemodynamic conditions present at this level try to explain the phenomenon. There are studies done on mice with a rapid progress.(2) Apolipoprotein E is until now widely incriminated in the pathogenesis of atherosclerosis (3), but only under certain vascular geometry in terms of vessel diameter and hemodynamic forces that are created during blood flow.

The most atheroma plates were present at the level of the aortic isthmus, towards the descending aorta. This disposition represents only one finding, because this paper has sought to highlight features of atheromatous, so the noted arrangement may not be considered a well supported one, other related parameters were not envisaged.

DISCUSSIONS

1. Morphometric study

The classical anatomic studied do not approach the morphometric details of the aortic arch. This information is valuable for certain specialties of modern medicine, which along with their development contributed to the completion of the anatomical data with more detailed information and brought about a closer approach of the anatomical variants and deviations from traditional descriptions.

Recently, vascular surgery, new techniques of medical imaging and interventional imagery abound in the interpretations and points of view with respect to aortic arch and its branches. They are looking to satisfy the different problems facing modern medicine. The fact is that the need for knowing the aortic arch anatomy, with possibilities for variation of this element finds application in the surgery of neck and thoracic surgery, endovascular surgery, angiography, Doppler ultrasound examinations etc.

Morphometric studies found in the literature are not numerous and present many different methods and approaches, with varying results, variables sometimes even contradictory. The methods of study are either the imagining ones either through anatomical dissection on bodies, prepared mostly with formalin solution. Preparation of corpses prior to examinations can alter the composition of the wall, thus influencing the results of vessels. The present study sought to limit those effects by making the measurements as soon as possible.

This study has tried to limit these effects by taking measurements as soon as possible. N.L. Wright published in 1969 a morphometric study of the aortic arch, conducted on a number of 100 fresh cadavers, using two research methods. One of them is based on the classic dissection aortas with direct measurements, applied to 50 of the 100 bodies. For the rest of the bodies, there has been used a different method, namely the development of moulds after aortic arch and its branches emergence, applying the same measurements as for the parts examined directly through dissection. The author's argument is that, this way, the results would be more accurate.(4)

Some of the measurements carried out by Wright coincide with the same performed in this study, and thus, the results obtained can be compared. For aortic arch, the average diameters obtained by Wright in the proximal arch is 24mm for men and 24.5 mm for women, the standard deviation of 4.87 for men, 5.57 for women, respectively. In the present study, higher values were obtained for men, an average of 26.1 mm with a standard deviation of 2.34, while for females the average was 21.68, with a standard deviation of 2.01. If according to Wright, the values of the two genders were about equal, in our study the difference between genders is notable, nearly 5mm, but statistically speaking, the population group examined by Wright had greater variability of values, as indicated by the standard deviation values.

In the aortic isthmus, the values obtained by Wright were 19 mm for males, 18.5 mm for females respectively with standard deviation values of 3.88 for females, 4.02 respectively. The values obtained in this study are 20.47 mm and 17.06 mm for men for women, with a standard deviation of 2.33 and 1.73 respectively. Although the recorded values are different, possibly due to subjects belonging to different populations, there is a direct proportionality between the values of the present study and those presented by Wright.

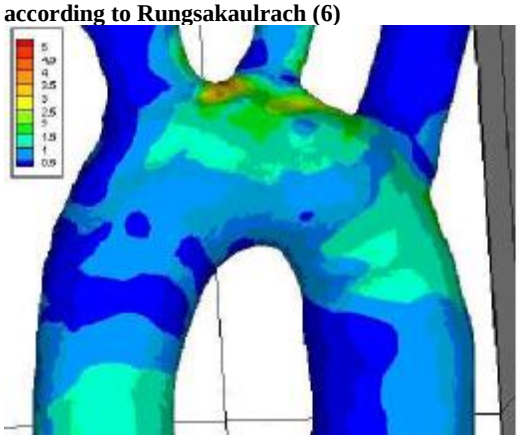
2. Atherogenesis

Atherosclerotic disease is the association of predisposing and determining genetic factors, together with metabolic disorders and hygienic-dietary changes leading to chronic vascular endothelium. Whatever the underlying cause, the response is characteristic to the arterial damage. Hemodynamic factors are factors that contribute to act locally contributing to the occurrence of arterial lesions in the areas of hemo-dynamic stress areas. The most common areas of atherosclerotic lesions and arterial bifurcations are the turning points and inflection.(5)

Due to the complexity of the relationship between these factors and individual diversity, the importance of this problem is major.

Hui Zhu and co-workers have shown that the geometry of the aortic arch and its diameter can be prone to the occurrence of such damage. Smaller diameters and more „sharp" aortic arch would lead to increased forces determining lesions at vascular wall level.(2)

Figure no. 4. Risk areas in the development of atherosclerotic plaques, "hot" areas having the highest risk according to Rungsakaulrach (6)



Rungsakaulrach, through the accomplished models on the aorta of mice, showed that the hemodynamic forces were increased over the outer wall in the vicinity of the aortic arch branches. These areas correspond to places where we found atheromatous plaque in our study. However, transposition of the data obtained in this study is still reserved for humans.(6)

CONCLUSIONS

- The morphometric study of the aortic arch showed how variation of the classical anatomical shape of aortic arch in the population of Sibiu County, compared for the two genders, establishing own values obtained by direct measurement as a result of the dissection, which summarises significant differences.
- After the emergence of the aortic arch branches, the measured diameters are gradually decreasing, so that at the level of the isthmus to register the small diameter of the arch. This pattern of values was present in all the analyzed parts. The lower part at the isthmus level for the collected pieces from men was of 14mm.
- For the parts collected from female cadavers, in general, the recorded values were lower than those of male bodies.
- Among the pieces examined, 28 of them were found to be atheromatous lesions at different levels. Only six of them were from female cadavers.
- Most plaques were present in the aortic isthmus, to the descending aorta.
- Calculation of average diameters showed values corresponding to literature citations.
- Anatomical variability is the basic feature of the results obtained, the highest variability of the aortic arch diameter values interested.
- The data obtained were compared with those in the literature which summarise the converging or particular aspects or with those of other authors, capitalizing on the results as objectively as possible to show the significance of the study.
- Embryological and clinical correlations stress the importance of the study and the results, putting into question other types of approaches and the need to continue the study, with its expansion and completion of the image over the issue, in order to increase the accuracy and relevance of statistics and the usefulness of such a study in the medical practice.

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