MORPHOMETRIC STUDY OF THE AORTIC ARCH BRANCHES

CĂLIN MOHOR[1]

[1] *"Lucian Blaga" University of Sibiu*

Keywords: *aortic arch branches, morphometric study*

Abstract: *Morphometry represents an important factual study in the evaluation of living organisms. The object of morphometry is to set precise limits in certain parameters (length, diameter, angles etc.) very useful in describing and comparing the characters 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. Morphometry involves determining some well-defined metrics, positioning toward clear landmarks and the removal of items that might influence the correct interpretation of these parameters. For this reason, I aim at performing a morphometric study on one of the most important elements of the vascular anatomy, which is not subject to the general rules of arterial division and morphometry, as it was shown in the first part of the paper.*

Cuvinte cheie: *ramuri arc aortic, studiu morfometric*

Rezumat: *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.) aspect foarte util în descrierea şi compararea caracterelor unui anumit obiect/organ, şi implicaţiile pe care le are variaţia formei asupra funcţiei. Este folosită frecvent în determinarea modificărilor formei organismelor vii, de-a lungul ontogenezei. 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. Din acest motiv, dorim să efectuăm un studiu morfometric pe unul din elementele anatomice vasculare cele mai importante, care nu se supune regulilor generale de diviziune arterială şi morfometrie, după cum a fost arătat în prima parte a lucrării.*

INTRODUCTION

Morphometry is an important object of study in the evaluation of living organisms. The object of morphometry is to set precise limits in certain parameters (length, diameter, angles, etc.)

Morphometry is useful in describing and comparing the characteristics of a particular object / organ, and the implications it has on the function of the shape variation. Morphometry involves determining some well-defined metrics, positioning toward clear landmarks and removal of items that might influence the correct interpretation of these parameters

During antogenesis, shape changes occur in living organisms, changes that may be determined by morphometry. Morphometry describe complex shapes and allows numerical and statistical evaluations and reports very useful in medicine and quantitative elements contribute to achieving anatomical descriptions.

Anatomy limited to direct discovery of constituents of the human body and describe them in a more or less subjective, but morphometry in anatomy began to be used together with the importance of statistical processing of data detection. Direct observations, together with detailed descriptions of numerical values that provide a high degree of accuracy combined approach led anatomic variants and anomalies, more accurate and more useful medical practice.

PURPOSE

The idea started from the observation that the anatomical depictions of the aortic arch and its branches, the represented at a variable distance from each other.

The classical anatomical descriptions, few authors refer to this as the practical origins of the left common carotid artery and its relations are much closer to the arterial brachiocephalic trunk. From here came the idea to determine exactly what the precise values of diameters, distances and angles of these crucial anatomical landmarks. Vascular surgery is what has made an outstanding contribution to the study of the aortic arch 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.

Foreign researchers have done morphometric studies through direct anatomical parts measurements and measurements and determinations by the latest imaging studies.

Because of its structural peculiarities, the aorta and its branches can adapt its diameter to the pressure or blood flow changes. This statement is made in this paper because the determinations are made in real time, but represent data obtained from the study of necropsy material that should not be taken and construed otherwise.

METHODS

The study is represented by the Morphometric study of the aortic arch branches in the adult.

It was developed within the Department of forensic

[1]Corresponding author: Călin Mohor, Str. Lucian Blaga, Nr. 2A, Sibiu, România, E-mail: calinmohor@gmail.com, Tel: +40745 528270
Article received on 10.02.2014 and accepted for publication on 29.04.2014
ACTA MEDICA TRANSILVANICA September 2014;2(3):238-242

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

Dissection was done after the rigors of medico-legal autopsy.

The parts were harvested from deceased persons for reasons which have not influenced or anatomical wholeness of the aortic arch. (for example, were not taken of the dead in traffic accidents, traumatized patients)

In relation to aortic arch branches were determined following measurements that interested internal and external morphology of these:

- dTrBC-inner diameter of arterial brachiocephalic trunk at home
- dCcS-inner diameter of the left common carotid artery at home
- dScS-inner diameter of left subclaviculary artery at home
- S1-length distance between the origin of the arterial brachiocephalic trunk and left common carotid artery
- S2- distance between the origin of the left common carotid artery and the left subclaviculary artery
- α1-angle value of the arterial trunk aortic arch and brachiocephalyc
- α2-the value of the angle of the left common carotid artery and aorta arch
- α3-the value of the angle of the left aortic arch and subclaviculary.

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

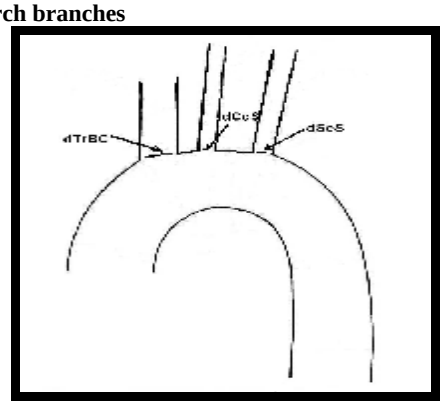
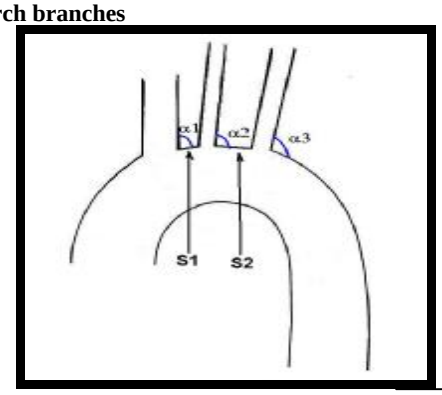


Figure no. 2. Measurements determined at the level of the aortic arch branches



Severing the 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.

RESULTS

Aortic arch Branches results

Diameters of the aortic arch branches

Diameters of the aortic arch branches recorded values that statistically haven't varied greatly.

In regards to the male sex, measurements have shown a minimum of 8 mm and a maximum of 16 mm for arterial brachiocephalyc trunk

The second branch of the aortic arch, the left common carotid artery of recorded values between 5 and 9 mm, and left subclaviculary artery values between 7-13 mm.

The average values for the three branches were 11,23 mm; 7.15 mm and mm for arterial trunk 9,23 brachiocephalyc, the left common carotid artery, and the left subclaviculară artery.

Thus the arterial brachiocephalyc trunk represented the most voluminous branch of the aortic arch.

To female gender, values recorded were lower. Diameter of arterial brachiocephalyc trunk had values between 7-11 mm with a mean value of 9 mm. ○The left common carotid artery had a mean value of 5.79 mm with values between 4-8 mm left subclaviculary artery has been in the range of 5-10 mm, with an average of 62 mm.

And in terms of the diameter of the aortic arch branches mean values determined for males being larger than those for women. The largest diameter was registered at brachiocephalyc, arterial trunk diameter in both men and women.

Mean values of diameters of the aortic arch branches compared to the two sexes Variability in relation to the diameters of the aortic arch branches is low as indicated by the values of the standard deviation. The greatest variability a arterial brahiocefalic trunk records, and the smallest variability is present at the level of the left carotid artery.

The distance between the branches of the aortic arch

For better insight into the aortic arch branches disposition were determined the distances between the three branches.

The male sex, on the whole, the distance between the origin of the arterial trunk brachiocephalyc and the origin of the left common carotid artery was less, with values ranging between 1-5 mm.

Between the origin of the left common carotid artery and the left subclaviculary artery origin distance has varied between 2-21 mm.

For women, like the male values of aortic arch branches distances were smaller for the distance between the origin of the arterial trunk brachiocephalyc and the origin of the left common carotid artery with values between 2-6 mm Between the origin of the left common carotid artery and the left subclaviculary artery origin distance had values between 1-9 mm

The mean distance between the origin of the aortic arch branches compared to the two genders show that the distance between the origin of the arterial brachiocephalyc trunk and left common carotid artery origin are very close (2,97-3.06-men\/women). This is supported and values obtained from the calculation of the standard deviation for this distance, the value being the same (0.99) indicates a very low jitter.

The distance between the origin of the left common carotid artery and left subclavian artery origin is subjected to a

higher variability, especially in males, with a standard deviation value of 3.33.

Hence, it can be concluded that most frequently common carotid artery originates closer to the brachiocephalic arterial trunk.

Angles between branches of the aortic arch and the aortic arch

With aortic arch branches diameters and distances of their origin, morphometric image angles are spread out over them.

To male sex angle between the arterial trunk and aortic arch brachiocephalyc had values between 35-80°. Between the aortic arch and the left common carotid artery, the angle had values between 35-75°, and between subclaviculary artery and aortic arch was formed an angle with values ranging between 46-102 degrees.

For the female sex the angle between the arterial trunk and aortic arch brachiocephalyc had values between 40-84 °, the extremes being larger than the males. Between the aortic arch and the left common carotid artery, the angle had values between 35-80°, and between subclaviculary artery and aortic arch was formed an angle with values between 45-93°.

Our values mean angles looks similar to the two sexes. The largest is the subclaviculary artery made with aortic arch. The smallest angle is one between common carotid artery and aortic arch. All angles are sharp angles, as an average value, both to women and to men. The angles of the arterial brachiocephalyc trunk and aortic arch and angle of the left common carotid artery and aortic arch are the same as an average value for the two sexes (61°, 53° respectively).

In terms of variability, aortic arch branches angles that do it are subject to a high degree of variation due to the large number of extreme values. Standard deviation shows the greatest variability in the angle formed between the brachiocephalic arterial trunk and aortic arch, both in males and in females. The smallest variability in both genders has the angle of the left common carotid artery.

Anatomical Variations

During dissection and during the study we encountered a series of anatomical variants of branches with its origins in the aortic arch. Anatomical variability of the aortic arch branches is made on account of some changes during the development of aortic arches. Limit of variation and anomaly is hard to determine, as long as there are pathological changes.

One of the most common anatomical variations, described in the literature having a frequency percentage of 27% (1,2) 10 to 22%, or by other authors (3) has been found in the present study two patients (2.46%). It is a variant of aortic arch arising only two branches, the first branch of the arch will create branches originating from the brachiocephalic arterial trunk normally - right subclavian artery and right common carotid artery - plus common carotid artery , but which normally originates from the aortic arch.

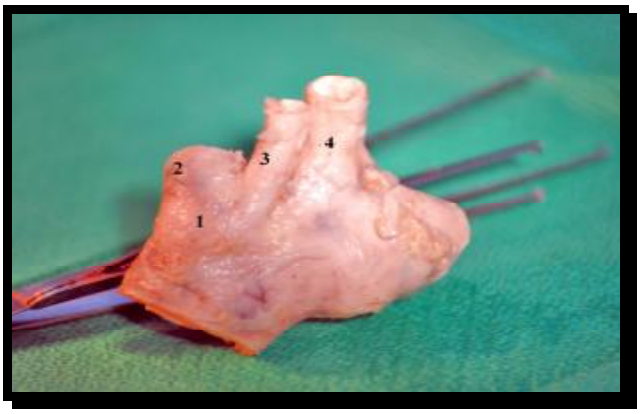
In one case (figure no. 3) common trunk left common carotid artery and unnamed artery (arterial brachiocephalic trunk) is very short paths before giving birth to the two branches practically subclavian artery origin is attached to the origin of brachiocephalic arterial trunk .

Studying the internal aspect, endolumenal arc shows the existence of a projection or Carine, which marks the common origin of the two vessels that would normally separate emergence.

In the second case, the common core is more clearly visible in both the interior and exterior.

Alternatively, the number of vessels that arise from the aortic arch is shown the embodiment in which the origin of the left vertebral artery of the aortic arch. Its origin is located between the origin of the left common carotid artery and left subclavian artery origin. This embodiment is described in the literature as having a frequency of 2.5 %.(1,2) In this study, 4 cases were found to such an embodiment, being 4.93 % .

Figure no. 3. The aortic arch from which two branches develop, trunk 1-2-3-CCS, TrBC, 4-ScStg



Atherosclerotic plaques

Atherosclerosis causes obstruction of the lumen of blood vessels throughout the body leading to ischemia in the territory distal obstruction, or infarction.

Determinism occurrence of this pathology is complex and intricate, being criminalized both genetic factors and environmental factors.

The spatial distribution in the development of atherosclerotic lesions throughout the vascular system varies depending on the individual. An important role is attributed to hemodynamic factors acting on the vessel wall is generally accepted that the most common sites for the occurrence of such lesions are areas where vascular geometry changes, places bending and division of the vessels.(4)

Although an important risk factor affecting vascular geometry hemodynamic parameters is difficult to correlate with other risk factors or determinants. Among the pieces examined, 28 of them were found atheromatous lesions at different levels. Only six of them were from female cadavers.

Table no. 1. Places where atheromatous lesions were present

	Branches		
	TrBC	**CCS**	**ScStg**
Female	**2**	**1**	**4**
Male	**14**	**10**	**14**

Most plaques were present at the origin of the brachiocephalic trunk and left subclavian artery. This provision is only a finding, as this paper has sought to highlight available atheromatous plaques so remarkable device can not be considered a well supported as they were watching, and other parameters related to this phenomenon.

DISCUSSIONS

Morphometric study

Classical medical descriptions don't tend to the morphometric details of aortic arch

A more recent morphometric study conducted in 2008 by Il Young Shin and his collaborators took a total of 25 corpses fixed with formalin, but diameter measurements were determined only for branches of the aortic arch, without specifying different values for the two sexes.(36) Thus, the Korean author presents the brachiocephalyc with an average

diameter of 18 mm, the left common carotid artery with a mean diameter of 9,5 mm and left subclaviculary artery with a diameter of 10.6 mm. For the measurements determined for aortic arch branches in the present work, the following values were recorded of diameters: 11,23 mm for arterial brachiocephalyc trunk, 7.15 mm for common carotid artery and left 9,23 mm for left subclaviculary artery. These values represent the diameters for males compared to the study of the above mentioned values obtained are lower.

In the Wright's study, there were also determined the 3 diameters, branches of the aortic arch, originally, there were the following averages: 12.5 mm in males and 12 mm in females for arterial brachiocephalyc trunk. The left common carotid artery in males and females had a mean value of 7,5 mm left subclaviculară artery and had the value of 10 mm for males and 9,5 mm for females. The values presented in the study of Wright are closer to those found in the present study. Standard deviation values are also close, indicating a similarity of values between our study and that of Wright, less in terms of arterial brachiocephalyc trunk, where Wright recorded a slightly higher jitter values.

To outlining an image full on aortic arch and its branches were determined the distances between the origin of the vessels with the aortic arch origin both in Wright's study as well as in the present study. The mean distance between the origin of the arterial brachiocephalyc trunk and left common carotid artery for men was 2,97 mm and for women by 3.06 mm. Wright indicates an average of 3 mm for both men and women. For the distance between the origin of the left common carotid artery and the left subclaviculary artery, the average was 6 mm or 7 mm for males for females in the study of Wright. 6,89 mm 5,2 mm for men women were respectively the values obtained in the present study. Regarding the second, the variability was larger than the first in both studies. The conclusion formulated by which affirm that the origin of the left common carotid artery is closer to the origin of the arterial brachiocephalyc trunk towards the left subclaviculary artery origin is supported and the study of Wright.

The measurements showed that the largest variability in the present study, are those of the angles formed between branches with emergence of aortic arch and it. The angle formed by the arterial brachiocephalyc trunk with aortic arch, the average was between 61,13° common carotid artery and the left aortic arch was recorded value of 53, 8° and the angle formed by the left subclavicular artery, the value of the angle was 68,13°. They represent the average values observed for male and female gender values were similar. In the study of Young Shin values for the same angles recorded respectively the value of: 65,3°, 46.9° and 63,8°. The difference in the study of Shin Young is that the greater the angle formed by the arterial brachiocephalyc trunk and aortic arch.

Anatomical variants

We have discovered two cases of aortic arches from which emerge two branches, meaning 2,46% of cases. These branches of the aortic arch were represented by:

- a trunk from which emerges the brachiocephalyc artery and the left common carotid artery, the latter being normally the emergence of aortic arch.
- the left subclavicular artery

This variant is referred to, in the anatomical literature, as „the bovine type", although it is also present in other mammals. Young Shin says that this variant has a frequency of 8% when Wright found this variant in 7% of cases.

Wright noted an important aspect of vessel morphology in this type of variant, met and referred to it in the present work, namely the presence of a linear, prominent ridges marking the origin of the aortic arch of this trunk. This is more or less well represented, and the original has more often than not an irregular shape that causes holes in branches and taking birth in that it does not present a circular but elliptical one.

Most authors consider that this option has the highest frequency of anatomical variants of the aortic arch. Piersol (1906) and Gray (1962), quoting Anson (38), States that this variant is the most common from the point of view of the origin of branches from the aortic arch, the classical variation 3 the branches.

Liechty and his collaborators in 1957, based on a survey conducted on 1,000 dead bodies present this as the second type of branching at the level of the aortic arch, with a frequency of 27.1%. Pop D. Popa, in 1982, showed same frequency percentage for this type of variation as Liechty.

In a more recent study, in 2010, Sangam describes a case setting it as the classification of the aortic arch done by Adachi, in type B, with a frequency of 11%. Also in 2010 Indumathi and his colleagues, in a study of 75 subjects who used both methods research classic dissection and angiographic examination establishes a rate of 6.52 % for men and 3.7 % for women, the only study that presents the frequency of gender.(5)

A study of the population of Kenya shows the presence of this variant in a percentage of 25.7 %.(6) The same approach is carried out in 2003 , the population of South Africa by Satypal and counted only. They say this type of variation is found in 3.4 % of cases.(7,8)

Marta L. Nelson, in 2001 conducted a study of Japanese men encountering an incidence of 1.03% variant to Toshiyki Saito showing a 10.9% in the Japanese population.(7,8) The second type of variant found at dissection in the study, in terms of the number of branches, is the left vertebral artery takes birth from the aortic arch between the emergence of the left common carotid artery and the left subclaviculary artery. The frequency of recorded was 4.83 m%.

Yazar f. presents in 2003 this type of variation in a proportion of 5%, in a variant of the research branches of the aortic arch.

A presentation to the vertebral artery in the Japanese population carried out in 2006 by Yamaki sets the presence of this variant with the aortic arch origin, as being present in a proportion of 5, 8 percent cited by Kubikovaă. Anson and Dasler set the frequency of the variations between 1-3% of the ones mentioned by Panicker.

Pop D. Popa and Liechty argue the presence in 2,5% of cases, respectively, the third type of variation as frequency encountered in the study. This includes a variant in its classification of type C with a rate of 4.3%.(4,40) the cause of this variation is an anomaly in embriogenesys. Normally, the backbone artery of both on the right and on the left side, emerges from the seventh intersegmentary artery, corresponding to the origin of the proximal portion of the subclaviculary; the distal portion is formed by merging the intersegmentary arteries into arteries of C2-C7 vertebrae. Where the intersegmentary persists cranially to the seventh intersegmentary artery, the origin of the vertebral artery will be from the aortic arch.

McElhinney Goldmuntz also impugned and genetic factors in the occurrence of these anatomic variations, indicating that 22q11 deletion would be responsible for the onset of altered morphogenetic processes in the formation of the vascular system, while also noting a recurrence in aortic arch double appearance.

CONCLUSIONS

- Morphometric study of the branches of the aortic arch showed the variation modality of aortic arch branches

emergence in the population of Sibiu County, compared for the two genders, setting own values obtained by direct measurementa after dissection, pointing out significant differences.

- With regard to the mean diameter of the aortic arch branches, the values determined for males are higher than those for females. The largest diameter recorded was the arterial brachiocephalic trunk diameter, both in men and women.
- The largest variability in the diameters of the aortic arch branches was found in the arterial brachiocephalyc trunk and the variance is less than the level present in the left carotid artery.
- For females, as well as for males, the values of the distance between the branches of the aortic arch were lower for the distance between the origin of arterial brachiocephalyc trunk and the left common carotid artery origin.
- The distance between the origin of the left common carotid artery to the origin of the left subclavian artery is subject to large variability, especially in men, and the standard deviation value. Hence, it can be concluded that most frequently, common carotid artery originates closer to the brachiocephalic arterial trunk.
- The average value of the angles looks similar in the two genders. The largest angle is made by the subclavian artery with the aortic arch. The smallest angle is the one between the common carotid artery and the aortic arch. All angles are acute angles, with mean values, both women and men. Angles of arterial brachiocephalic trunk and the aortic arch and the angle between the left common carotid artery and aortic arch are the same in terms of the average value in the two genders.
- Most plaques were present at the origin of the brachiocephalyc trunk and the left subclavian artery
- Anatomical variability is the basic characteristic of the obtained results, the greatest variability interested the values of the distances between the branches of the aortic arch and the angles between the aortic arch and its branches.
- There have been highlighted and described the most common variants of number of aortic arch branches, namely the variant with two branches, in which the brachiocephalyc origin and that of the left common carotid artery are common and the one with four branches, in which the left vertebral artery represents the branch of the aortic arch.
- The data obtained were compared with those in the literature which summarise the converging or particular aspects of other authors, capitalizing on the results as objectively as possible, in order to show the significance of the study.

REFERENCES

1. Bergman RA, Thompson SA, Afifi AK, Saadeh FA. Compendium of Human Anatomic Variation: Catalog, Atlas and World Literature, Urban & Schwarzenberg, Baltimore and Munich; 1988.
2. Papilian V, Russu IG, Papilian VV. Manual practic de disecţie", Editura Medicală, Bucureşti; 1959.
3. Piersol GA. Human Anatomy 6th ed.,1906, Philadelphia and London: J. B. Lippincott Company.
4. Pop D. Popa I. Sistemul arterial aortic – patologie şi tratament chirurgical, vol. 1, Editura Medicală, Bucureşti; 1982.
5. Shin IY, Chung YG, Shin WH, Im SB, Hwang SC, Kim BT. A morphometric study on cadaveric aortic arch and its major branches in 25 korean adults: The perspective of endovascular surgery, J Korean Neurosurg Soc 2008;44:78-83.
6. Snell RS. Clinical Anatomy by systems, Lippincott Williams&Wilkins, Baltimore; 2007.
7. Sangam MR, Anasuya K. Arch of aorta with bi-carotid trunk, left subclavian artery, and retroesophageal right subclavian artery, Folia Morphol 2010;69(3):184-186.
8. Stewart JR, Kinkaid OW, Edwards JE. An atlas of vascular rings and related malformations of the aortic arch system", Springfield (IL); 1964.
9. Seres-Sturm M, Maros TN, Seres-Sturm L. The abberant retroesophageal right subclavian artery, RJME 1985;31(3):183-186.