

# Manole A.M., Iliescu D.M., Baz R., Bordei P. **Morphological characteristics of the aortic arch organization**

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#### ABSTRACT

Our study was performed on 228 cases by dissection, by plastic injection followed by corrosion or dissection and by simple and CT angiography study. Each morphological aspect was assessed on a different numbers of cases, as long as the same case could not provide data on all studied elements. We assessed: the number of branches that originate from the aortic arch, the level of origin and the morphological type of the aortic arch. In terms of number of branches emerging from the aortic arch, most commonly are three branches, in 48.48% of cases, describing them 3 variations: separation of the three classical branches in 45,96% of cases, in 1.51% of cases the left common carotid artery emerged from the brachiocephalic trunk while the other two branches being represented by a vertebral artery and the left subclavian and in 1.01% by the right subclavian artery with retroesophageal traject, by a bicarotid arterial trunk and the left subclavian artery. In 28.70% of the cases were four branches, as follows: in 13.13% of cases the fourth branch was represented by the left vertebral artery, in 7.07% of cases there was the inferior thyroid artery, in 4.04% of cases the brachiocephalic arterial trunk was missing and the right subclavian artery originate from the aortic arch and presented a retroesophageal traject, in 3.03% of cases the fourth artery was the ascending cervical and in 1.51% of cases all four arteries had their origins in the aortic arch with no brachiocephalic trunk. In 22.73% of cases from the aortic arch originated only two branches: in 19.70% of cases the left common carotid originated in the brachiocephalic trunk, so the second branch was the left subclavian and in 3.03% of the cases there

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Department of Anatomy, Faculty of medicine, University "Ovidius" Constanța, Romania Aleea Universitatii, Nr. 1, Campus B Constanța, Romania dan@anatomie.ro were two brachiocephalic trunks. Regarding the level of origin from the aortic arch, we found that only the brachiocephalic arterial trunk showed versions of origin: in 64 61% of the cases the brachiocephalic trunk had its origin in the horizontal segment of the aortic arch, in 21.54% of cases the origin was located at the limit between the ascending and horizontal segments and in 12.31% of cases the origin was from the ascending segment of the aortic arch. In only 1.54% of the cases the left subclavian artery originated from the descending segment of the aortic arch.

Keywords: aortic arch: branches, origin, morphological type

#### Introduction

It is well known that heart and vascular illnesses now occupies the first place in the pathology of modern society, which has led to declare them as the public enemy number one. Ever-increasing frequency of the arterial pathology, especially traumatic, degenerative and congenital, the invalidation of the active ages, the duration and the progressive nature of this severe and aggravating disease, all are features of cardiovascular diseases. The etiology of this disease includes many factors, from genetic inheritance of the individual to a multitude of elements such as macro and microclimate, infection, trauma, etc. The problem of the cardiovascular diseases is aimed all over medical world; within the WHO there's a section that deals with the prevention and control of the cardiovascular disease.

In the study of cardiovascular diseases, the knowledge of the anatomy and pathophysiology of the heart, aorta and its branches is a primordial condition. Cardiovascular surgery (open heart surgery) took an impressive development in recent years due to new acquisitions in exploration, new operative techniques and use of increasingly refined and sophisticated equipment. The search for new cardiovascular operative techniques imposes new anatomo-surgical studies, which led to the re-evaluation of the studies on heart, aorta and great vessels; a special attention is aimed towards the aortic arch: morphometry, structure, collateral branches and their variations, congenital abnormalities. The anatomical variations of the aortic arch and its branches were and are still described nowadays: the middle thyroid artery was described in 1772 simultaneously by Neubauer and Erdmann [quoted by 1]. According to Guillem [1], the first description of an aortic anomaly dates from eighteenth-century when Hommel [cited by 1] introduces the term "lusus naturae" (the game of nature), hence the subsequent term of "arteria lusoria ". Right aortic arches are rare congenital anomalies, but not exceptional, their frequency was 0.1% [Hastreiter, Maas, quoted by 1]. The first case of right aortic arch is classically attributed to Fioratti and Aglieti in 1739 [1]. It took more than two centuries until the first successful surgical treatment of a vascular ring is reported [Gross, 1948, cited by 1]. In 1948 Edwards proposed the first universally recognized classification of this data [1].

## **Materials and methods**

Our study was performed on 228 cases of which 61 cases by dissection, 42 cases of plastic injection (Technovit 7143) followed by dissection or corrosion, 52 cases were represented by single angiography and 73 cases of angioCT. Each morphological aspect was assessed on a different numbers of cases because the same case could not provide data on all studied parts. The angiographies came from Medimar Exploration Center in the Emergency Hospital in Constanta, being executed on a GE LightSpeed 16 Slice CT Scanner. We also examined angiographies from Pozimed Diagnostic Center, being executed on a GE LightSpeed VCT64 Slice CT Scanner. We evaluated: the number of branches that originate from the aortic arch, the level of origin and the morphological type of the aortic arch.

### **Results**

The number of branches emerging from the aortic arch was studied on 198 cases; the most common type of the aortic arch is the one with three branches, in 96 cases (48.48% of cases), describing it 3 variations:

1. classical separation of the three branches (brachiocephalic arterial trunk, left common carotid and left subclavian) in 91 cases (45.96% of cases, Figure 1);



Figure 1 - Aortic arch with three branches; the left common carotid is the closest to the brachiocephalic trunk

2. in three cases (1.51% of cases) the left common carotid artery originated from the brachiocephalic trunk while the other two branches being represented by a vertebral artery and the left subclavian;

3. in 2 cases (1.01% of cases) the right

subclavian artery, originating from the aortic arch showed a retroesophageal traject, the other two branches being represented by a bicarotid arterial trunk and the left subclavian artery (Figure 2).



Figure 2 - Right subclavian artery with retroesophageal traject. Bi-carotid trunk

In 57 cases (28.70% of cases), the aortic arch gave loose four branches, with several variations:

1. most frequently, in 26 cases (13.13% of the cases), the fourth branch was represented by the left vertebral artery;

2. in 14 cases (7.07% of cases) the fourth branch of the aortic arch was represented by an inferior thyroid artery (Figure 3);

3. in 8 cases (4.04% of cases) there was no brachiocephalic arterial trunk, the left subclavian artery originating from the aortic arch with retroesophageal traject, the other two branches of the aortic arch being represented by a bicarotid arterial trunk and a left subclavian artery;



Figure 3 - Inferior thyroid artery originating from the aortic arch between the brachiocephalic trunk and the left common carotid

4. in 6 cases (3.03% of cases) the fourth artery was the ascending cervical artery (Figure 4);



*Figure 4 - Ascending cervical artery originating from the aortic arch* 



Figure 5 - Left common carotid artery originating from the brachiocephalic trunk

5. in 3 cases (1.51% of cases) all four classic branches originated from the aortic arch (Figure 6).



*Figure 6 – Absence of the brachiocephalic trunk; the 4 arterial branches originate directly from the aortic arch* 

In 45 cases (22.73% of cases) there was no brachiocephalic trunk, the aortic arch giving only two branches, with two options: 1. most commonly, the left common carotid originated in the brachiocephalic trunk in 39 cases (19.70% of cases), the second branch being the left subclavian artery; 2. in 6 cases (3.03% of cases), there were two brachiocephalic arterial trunks, right and left (Figure 7).



Figure 7 - Coexistence of two brachiocephalic trunks

Assessing the level of origin of the branches of the aortic arch in 195 cases, we found that only the brachiocephalic arterial trunk shows variations of origin, the other aortic branches starting from the horizontal segment of the arch, except for three cases (1.54% of cases) when the left subclavian artery originated from the descending segment of the aortic arch. In 126 cases (64.61% of cases) the brachiocephalic trunk originated from the horizontal segment of the aortic arch, in 42 cases (21.54% of cases) the origin was located at the limit between the ascending and the horizontal segments and in 24 cases (12.31% of cases) the origin was from the ascending segment of the aortic arch.

The aortic arch traject and shape are related to the traject of the ascending and descending segments. The ascending segment of the aorta may present three types of traject: supero-medial oblique to the right, vertical or supero-lateral oblique to the left. When the two segments of the aorta, the ascending and the descending one are closer (33.9 to 40 mm), the aortic arch is considered to be "narrow", its horizontal portion is short and the distance between its collateral branches is reduced (Figure 8). When the two aortic segments are far apart (over 40 mm), the aortic arch is "large" and the distance between the three branches is bigger. The classical type, found in 57 cases (44.53% of cases) showed a regular version, with the three branches equidistant from one another and another version in which the left common carotid artery may be located closer to the brachiocephalic trunk or to the left subclavian artery.



Figure 8 - "Narrow" aortic arch: transverse distance is 38.5 mm

## Discussions

Regarding the number of arterial branches emerging from the aortic arch, classical authors noted that, most frequently, arise three arteries but statistics are not quite well defined. [2] on 33 cadavers, founds three branches in a proportion of 82% of the cases, 12% of the cases with two branches (males only), and 6% of the cases with 4 branches (only in females). [3] founds 3 branches in 84% of the cases. In comparison, we found three branches in a lower percentage of 36.04% than [2] and of 48.04% than [3]. In our study we met more frequently the variation with four branches, up 22.79% than [2] and with two branches, up to 10.73% than [2]. Referring to the inferior thyroid artery, Olivier [quoted by 4] finds it frequently as having its origin in the aortic arch, rarely in the right common carotid and exceptionally from the left internal thoracic artery. For [5], the origin of the inferior thyroid artery is, in 75% of cases, from the brachiocephalic trunk, being rare from the aortic arch, even exceptional. Braine and Funck [cited by 4] found that the aortic origin of the inferior thyroid artery is to the right of the midline, and [6] states that in 15% of the cases the inferior thyroid artery origin is inconsistent. Also [6] states that the brachiocephalic trunk may be absent, so all four arteries will separately originate from the aortic arch. A more complex statistic we met in [7], which describe several variants of the aortic arch branches. Thus, he founds the origin of the left vertebral artery from the aortic arch in 7-8% of cases (we found it more frequently with 5.13%) and the inferior thyroid in 1% of cases (we found it more frequently with 6.07%). Lippert [7] found in 1% of cases the presence of the "arteria lusoria" (the right subclavian artery as the final branch of the aortic arch, passing under the ascending aorta) a variation described by [8], but we did not find this version. Also [8] gives a percentage of less than 1% of cases for each of the following: two brachiocephalic trunks (we found 2.03% higher), bicarotid trunk (we found a similar percentage), missing brachiocephalic trunk (we found 0.51% higher), left brachiocephalic trunk (we found 2% higher), right aortic arch and double aortic arch (aspects that we have not met). According to [9], the bicarotid trunk is associated with retroesophageal right subclavian artery or with a common trunk for left subclavian and left vertebral arteries. [10] describes a common arterial trunk formed by the brachiocephalic trunk, left common carotid and left subclavian.

Another author [4] states that the origin of the brachiocephalic trunk may be at the union of the ascending aorta with the horizontal segment, 3-5 mm anterior and to the right of the left common carotid. Also, [2] shows that the brachiocephalic trunk arises from the ascending aortic segment in 61% of cases, while we found it in a lower percentage of 48.69%.

### Conclusions

The study of the aortic arch shows a particular interest in terms of morphology, pathophysiology and clinics due to frequency of variations and diseases (congenital or acquired) at this level; it also shows an imaging interest due to frequent ultrasounds and angiographies within medical practice but mostly a surgical interest, by the impressive development of the cardiovascular surgery, the cardiac and aortic grafts and the coronary bypasses.

This study shows that, according the origin and the arrangement of its branches, the aortic arch may be described as : the classical type (trident) and variations (two or four branches, or variations of the samples with three branches, such as a left common carotid artery originating from the brachiocephalic trunk, with the third branch the left vertebral artery). The variations of the aortic arch are more frequent, 107 cases (54.04% of cases) than the classic aspect with three branches; thus, we describe a regular version, with the three branches at equal distance from each other, and another variation with the left common carotid artery closer to the brachiocephalic trunk or to the left subclavian artery. Among the variations, most commonly we met origin of the left vertebral artery from the aortic arch in 29 cases (14.65% of cases), both in cases with three or four aortic branches (more frequently).

The statistical differences between the results we found and the existing data in the literature may result from the total number of studied cases and also from the working methods.

## **References**

- Guillem Ph., Triboulet J.P., Fontaine Ch. & Bailleul J.P. (1999). Les arcs aortique droits: classification anatomique et embryologique. *Morphologie.* 83 (262), 13-38
- Grande N.R., Costa A., Silva E., Sousa Pereira A. & Aguas A.P. (1995). Variations in the Anatomical Organization of the Human Aortic Arch. A Study in a Portuguese Population. *Bull. Assoc.Anat.* 244, 19-22.
- Il-Young Shin, Yong-Gu Chung, Won-Han Shin, Soo-Bin Im, Sun-Chul Hwang & Bum-Tae Kim. (2008). A Morphometric Study on Cadaveric Aortic Arch and Its Major Branches In 25 Korean Adults: The Perspective of Endovascular Surgery. J.Korean.Neurosurg.Soc. 44, 78-83.
- 4. Paturet G. (1964). *Traité d'Anatomie Humaine*. (pp. 549-570). Paris: Ed. Masson
- 5. Adachi B (1927). Das arterien system der Japaner, T 1,2, Kyoto. Suppl. of Acta Schol med. Univ. Imper. vol. IX.
- Kamina P. (2007). Anatomie clinique. Tome 3. (pp. 132-133). Paris: Ed. Maloine.
- 7. Lippert H. & Pabst R. (1985). *Arterial Variation in Man.* (pp. 3-9). Munchen: J.F. Bergman Verlag.
- Avisse C., Marcus C., Delattre J.F., Cailleiez-Tomasi J.P. & Ladan-Marcus V. (1998). Right non-recurrent inferior laryngeal nerve and arteria lusoria: the diagnostic and therapeutic implications of an anatomic anomaly. Review of 17 cases. Surg.Radiol.Anat. 20, 227-232.
- 9. Gluncic V. & Marusic A. (2000). Association of truncus bicaroticus, common trunk of the left subclavian and vertebral arteries, and

retroesophageal right subclavian artery. Ann. Anat. 182, 281-283.

10. Zamir M. & Sinclair P. (1991). Origin of the brachiocephalic trunk, left carotid, and left subclavian arteries from the arch of the human aorta. *Invest.Radiol.* 26, 128-133.