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Full Length Research Paper

Aortic branch variations: An anatomical study in 900 subjects

Federico Mata-Escolano[1], Luis Aparicio-Bellver[2], Vicente Martinez-Sanjuan[1] and Juan A. Sanchis-Gimeno[2]*

[1]Eresa General University Hospital of Valencia, Spain.
[2]Department of Anatomy and Human Embryology, Faculty of Medicine, University of Valencia, Spain.

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The anatomic variations in the branches arising from the aortic arch in 900 Caucasian subjects and the exact origin of the right subclavian artery, the right common carotid artery, the left common carotid artery, the left subclavian artery, the right vertebral artery, and the left vertebral artery were analyzed by means of angio-computerized tomography. Seven hundred and thirty-four subjects (81.55%) had three branches arising from the aortic arch, 126 subjects (14%) had 2 branches and 40 subjects (4.44%) had 4 branches. In addition, the following anatomic variations were found: The left common carotid was observed arising from the brachiocephalic trunk in 80 subjects (8.88%); the left carotid and the brachiocephalic trunk arose from a common stem, which in turn arose directly from the aortic arch in 46 subjects (5.11%); the right common carotid and the right subclavian artery (arteria lusoria) arose directly from the aortic arch in 30 (3.33%) and 4 subjects (0.44%), respectively; the left vertebral artery and the right vertebral artery arose directly from the aortic arch in 16 (1.77%) and 2 subjects (0.22%), respectively. The study revealed that more than 20% of the Caucasian subjects had anatomical variations in the aortic arch branches.

Key words: Aortic arch, arteries, vessels.

INTRODUCTION

Theoretically, human body anatomy is very well known as should be the case of the number of branches arising directly from the human aortic arch. Normally, three branches arise directly from the human aortic arch, these being the brachiocephalic trunk (BCT), the left common carotid artery (LCCA), and the left subclavian artery (LSA). It is considered as normal that the right common carotid artery (RCCA) and the right subclavian artery (RSA) arise from the BCT. Moreover, the right vertebral artery (RVA) arises from the right subclavian artery (RSA) and the left vertebral artery (LVA) from the left subclavian artery (LSA).

Currently, the development of modern imaging techniques makes it possible to study the human aortic arch branches *in vivo*. The use of imaging techniques is increasing the knowledge of the anatomy of the branches that arise from the aortic arch (Lemke et al., 1999; Goray et al., 2005; Natsis et al., 2009; Fawcett et al., 2010). The exact anatomy of an aortic arch malformation and its relationship to adjacent structures can be accurately defined by computerized tomography (CT) and magnetic resonance (MR). Both methods allow excellent delineation of all patent vessels by contrast enhanced angiography (angio-CT and angio-MR) with comparable image quality and the possibility of 3-D display of the malformation (Kellenberger, 2010).

In the light of the aforementioned, we present the largest study, to our knowledge, carried out on

*Corresponding author. E-mail: juan.sanchis@uv.es. Tel: + 34 96 3983518. Fax: + 34 96 3864815.

Abbreviations: BCT, Brachiocephalic trunk; **LCCA,** left common carotid artery; **LSA,** left subclavian artery; **RCCA,** right common carotid artery; **RSA,** right subclavian artery; **RVA,** right vertebral artery; **LVA,** left vertebral artery.

Figure 1. Angio-CT showing the 'normal' three branches arising from the aortic arch. From left to right: the BCT, the LCCA, and the LSA.

Caucasians using angio-CT that analyzes the variations in the number of branches arising directly from the human aortic arch. In addition, we also analyzed the exact origin of the RSA, the RCCA, the LCCA, the LSA, the RVA, and the LVA.

MATERIALS AND METHODS

We carried out a four-year prospective study in order to quantify the number of branches arising directly from the human aortic arch. We analyzed a large sample of 900 Caucasian volunteers. The mean age of the 900 subjects was 62.84 ± 15.04 years old (range, 18 to 88 years). There were 400 women (44.44%) and 500 men (55.55%). All protocols were approved by the Committees of Ethics and Research of the Faculty of Medicine, University of Valencia. The work was performed in accordance with the World Medical Association's Declaration of Helsinki and written informed consent was obtained from all subjects. Subjects who were diagnosed with cardiovascular pathology before the study were excluded. No subjects had either clinical symptoms of cardiovascular pathology during the study. We analyzed these kinds of subjects because we wanted to study variations of the anatomical normality in asymptomatic subjects.

We quantified the number of branches arising directly from the aortic arch and analyzed the exact origin of the RSA, RCCA, LCCA, LSA, RVA, and LVA arteries by means of angio-CT. The angio-CT study was carried out with a LightSpeed ultra CT (General Electric Medical Systems, Milwaukee, WI, USA). The device used can make 16 slices per second; the slice thickness was 0.63 mm. Iopamidol 300 (Bracco UK. Ltd, High Wycombe, Bucks, UK) intravenous contrast medium was administered during the study (100 ml). Image reconstructions were made with Voxar 3D software (Barco, Kortrijk, Belgium).

RESULTS

Of the 900 subjects examined, 734 (81.55%) presented 3 branches (for example, BCT, LCCA, and LSA, in that order) arising directly from the human aortic arch (Figure 1). In that typical branching pattern, the RCCA and the RSA arose from the BCT, the RVA arose from the RSA and the LVA arose from the LSA. Nevertheless, we also found 126 subjects (14%) that presented 2 branches and 40 subjects (4.44%) that presented 4 branches that arose from the aortic arch (Figures 2 and 3).

In addition, we found the following anatomic variations in the origin of the arteries: the LCCA was observed arising from the BCT in 80 subjects (8.88%); the LCCA and the BCT arose from a common stem, which in turn arose directly from the aortic arch in 46 subjects (5.11%); the RCCA and the RSA (aberrant RSA or arteria lusoria) arose directly from the aortic arch in 30 (3.33%) and 4 subjects (0.44%), respectively; the LVA and the RVA arose directly from the aortic arch in 16 (1.77%) and 2

Figure 2. Angio-CT showing only two branches arising from the aortic arch. From left to right: the BCT and the LSA. The LCCA was observed arising from the BCT.

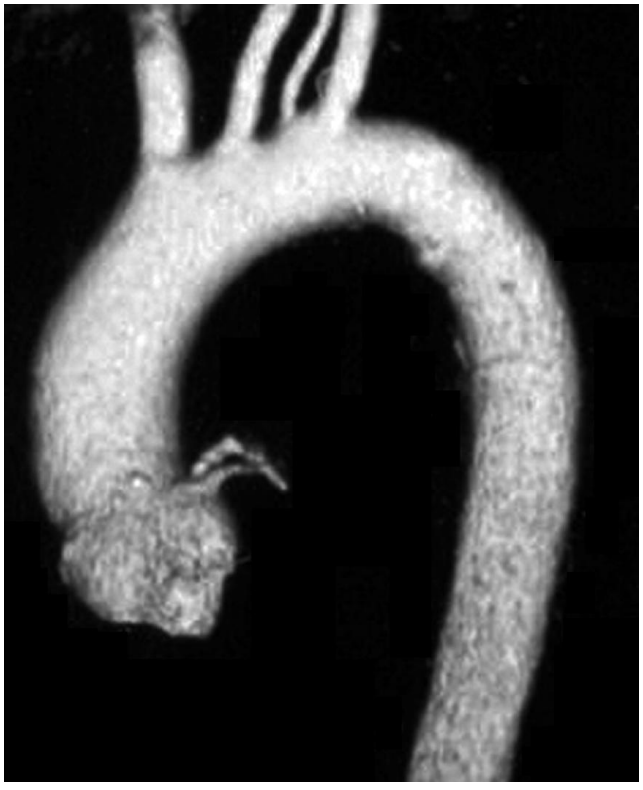

Figure 3. Angio-CT showing four branches arising from the aortic arch. From left to right: the BCT, the LCCA, the LVA and the LSA.

subjects (0.22%), respectively.

DISCUSSION

We have analyzed the number of branches arising directly from the human aortic arch and the exact origin of the RSA, the RCCA, the LCCA, the LSA, the LVA, and the RVA in a large sample of Caucasian subjects. The exact anatomy of an aortic arch malformation and its relationship to adjacent structures can be accurately defined by CT (Kellenberger, 2010); thus we used this technique to study the aortic arch branches. Moreover, we used angio-CT because it has the great advantage of making a hospital stay unnecessary. Another of the most important points of the study is the large cohort we analyzed with this technique. In addition, angio-CT makes it possible to obtain anatomic images *in vivo* simulating a "virtual dissection", thus similar results can be obtained to those acquired when performing cadaveric human dissections.

Natsis et al. (2009) in an angiographic study carried out on 633 subjects, described eight types (I to VIII) of the aortic arch; Type I being the most common type (83%), that is, the "normal" aortic arch giving rise to three branches: the BCT (or innominate artery), which then branches into the RSA and RCCA, the LCCA and the LSA. We also found the same normal pattern. Similar results were found in the classic study carried out on cadavers by Thomson (1893) and in the cadaveric studies carried out by Grande et al. (1995) and by Shin et al. (2008). However, Williams et al. (1932) and McDonald and Anson (1940) observed that only approximately 50% of Afro-Americans have the most common type of aortic arch. More recently, Nelson and Spark (2001) and Nayak et al. (2006) observed that more than 90% of the American-Japanese and Indian cadavers they studied have the most common type of the aortic arch. Aortic arch anomalies are usually incidental findings on imaging studies (Kellenberger, 2010). These anatomical anomalies of the aortic arch are usually asymptomatic (Poultsides et al., 2004; Chahwan et al., 2006; Natsis et al., 2009) as was the case in the subjects we analyzed.

We also found the presence of an aberrant RSA or arteria lusoria in 0.44% of the subjects we analyzed. Arteria lusoria is the most common anomaly of the aortic arch, occurring in 0.5 to 2.5% of individuals (Myers et al., 2010). Arteria lusoria is usually asymptomatic because the aberrant artery does not form a complete vascular ring around the esophagus and trachea, and is most often discovered during the course of evaluation of other mediastinal anomalies (Myers et al., 2010). Although these variations are often asymptomatic, they have been described as being the cause of a condition called "dysphagia lusoria". This situation is characterized by difficulty in swallowing and pain in some cases, due to the pressure applied by the artery onto the wall of the esophagus (Natsis et al., 2009).

Results obtained in the present study are of special importance for surgeons. Preoperative angio-CT can be ideal for studying the anatomy of the aortic branches. Surgeons can obtain an idea of what they are going to find before performing surgery. In addition, the results of this kind of study may be of interest to surgeons when they cannot carry out radiologic studies before surgery (that is emergency surgery on a patient in a critical condition) because, as was described in this study, the anatomy of aortic branches is different in approximately 20% of subjects and knowing this can help to anticipate possible complications during surgery. Moreover, we have found variations in the aortic branches. An explanation for the variations in the aortic arch has been thought to be related to a different development of the aortic branches during the embryonic period (Barry, 1951). Nevertheless, ethnicity may be another cause for the differences, as has been suggested by other authors (Williams et al., 1932; McDonald and Anson, 1940). Based on this, we analyzed a large sample exclusively made up of Caucasian subjects.

In conclusion, the present study has shown that approximately 20% of subjects have a 'non normal' anatomy of the aortic branches, if we take into account that a normal anatomy has three branches arising directly from the aortic arch: The BCT, the LCCA and the LSA.

REFERENCES

Barry A (1951). The aortic arch derivatives in human adult. Anat. Rec., 111(2): 221-238.

Chahwan S, Miller MT, Kim KA, Mantell M, Kirksey L (2006). Aberrant right subclavian artery associated with a common origin of carotid arteries. Ann. Vasc. Surg., 20(6): 809-812.

Fawcett SL, Gomez AC, Hughes JA, Set P (2010). Anatomical variation in the position of the BCT (innominate artery) with respect to the trachea: a computed tomography-based study and literature review of Innominate Artery Compression Syndrome. Clin. Anat., 23(1): 61-69.

Goray VB, Joshi AR, Garg A, Merchant S, Yadav B, Maheshwari P (2005). Aortic arch variation: a unique case with anomalous origin of both vertebral arteries as additional branches of the aortic arch distal to left subclavian artery. Am. J. Neuroradiol., 26(1): 93-95.

Grande NR, Costa e Silva A, Pereira AS, Aguas AP (1995). Variations in the anatomical organization of the human aortic arch. A study in a Portuguese population. Bull. Assoc. Anat. Nancy, 79(244): 19-22.

Kellenberger CJ (2010). Aortic arch malformations. Pediatr. Radiol., 40(6): 876-884.

Lemke AJ, Benndorf G, Liebig T, Felix R (1999). Anomalous origin of the right vertebral artery: review of the literature and case report of right vertebral artery origin distal to the left subclavian artery. Am. J. Neuroradiol., 20(7): 1318-1321.

McDonald JJ, Anson BJ (1940). Variations in the origin of arteries derived from the aortic arch, in American whites and negroes. Am. J. Phys. Anthropol., 27(1): 91-107.

Myers PO, Fasel JH, Kalangos A, Gailloud P (2010). Arteria lusoria: developmental anatomy, clinical, radiological and surgical aspects. Ann. Cardiol. Angeiol. Paris, 59(3): 147-154.

Natsis KI, Tsitouridis IA, Didagelos MV, Fillipidis AA, Vlasis KG, Tsikaras PD (2009). Anatomical variations in the branches of the human aortic arch in 633 angiographies: clinical significance and literature review. Surg. Radiol. Anat., 31(5): 319-323.

Nayak RS, Pai MM, Prabhu LV, D'Costa S, Shetty P (2006). Anatomical organization of aortic arch variations in the India: embryological basis and review. J. Vasc. Bras., 5(2): 95-100.

Nelson ML, Sparks CD (2001). Unusual aortic arch variation: distal origin of common carotid arteries. Clin. Anat., 14(1): 62-65.
Poultsides GA, Lolis ED, Vasquez J, Drezner AD, Venieratos D (2004). Common origins of carotid and subclavian arterial systems: report of a rare aortic arch variant. Ann. Vasc. Surg., 18(5): 597-600.
Shin IY, Chung YG, Shin WH, Im SB, Hwang SC, Kim BT (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(2): 78-83.
Thomson A (1893). Third Annual Report of Committee of Collective Investigation of Anatomical Society of Great Britain and Ireland for the Year 1891-92. J. Anat. Physiol., 27(Pt 2): 183-194.
Williams GD, AFF HM, Schmeckebier M, Edmonds HW, Graul EG (1932). Variations in the arrangement of the branches arising from the aortic arch in American whites and negroes. Anat. Rec., 54(2): 247-251.