Clinically Relevant Variations in the Branching Pattern of Arch of Aorta - Research Article

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Abstract: Anatomical variations in the branching pattern of arch of aorta are significant for diagnostic, surgical, and interventional procedures of the thorax and neck and the aim of the study is to analyze the anatomical variations in the branching pattern of arch of aorta. The purpose of this study is to review the anatomical variations in branching pattern of arch of aorta in fifty adult human cadavers (M: 42, F: 8) dissected in the department of anatomy, Siddhartha medical college, Vijayawada for five consecutive years from 2013 to 2017. The three branches of the arch of aorta were normal in 41 cadavers in the present study. In 9 cadavers, the variations were observed. In five male cadavers and in a female cadaver, the two branches of arch of aorta were the common trunk of brachiocephalic trunk and left common carotid artery and the left subclavian artery. In two male cadavers, the branches were four including the origin of left vertebral artery from arch of aorta. In a female cadaver, the three branches of arch of aorta were as follows: common trunk of brachiocephalic trunk and left common carotid artery, the left vertebral artery and the left subclavian artery. Head and neck surgeons and interventional radiologists should be aware of aortic arch variations. Computerized tomography angiography is a reliable imaging method for demonstrating anatomical features and variations of the arch of aorta.

Keywords: Arch of Aorta, Brachiocephalic Trunk, Left Common Carotid Artery, Left Subclavian Artery, Left Vertebral Artery

1. Introduction

In the classical anatomical configuration, the aortic arch is left sided and the most common branching pattern of the aortic arch comprises of three vessels; the brachiocephalic trunk, the left common carotid artery, and the left subclavian artery from right to left. The brachiocephalic trunk branches into right subclavian artery and right common carotid artery. This branching pattern occurs in 64.9–94.3% of the cases and it is described as normal. [1-2] Development of the arch of aorta takes place during the third week of gestation. Six pairs of aortic arches, the so-called branchial arch arteries, develop between the ventral and dorsal aortae. The variations of the aortic arch can be explained by the persistence of segments of the aortic arches that normally regress or disappearance of segments that normally remain, or both. [3-4] The purpose of this study was to clearly review the anatomical variations in the branching pattern of the arch of aorta in the fifty dissected human cadavers in our department of anatomy. The anatomical variations in the branching pattern of arch of aorta are significant for diagnostic and surgical procedures in the thorax and neck.

2. Material and Methods

In the routine educational dissection for the undergraduate students in the department of anatomy, Siddhartha medical college, Vijayawada for the academic years (2013-2017), the anatomical variations in branching pattern of arch of aorta in fifty adult human cadavers (M: 42, F: 8) were observed carefully after following the standard dissection procedures. The variations in the branching pattern of arch of aorta were
noted and photographed.

3. Results

The three branches of the arch of aorta were normal in 41 cadavers in the present study. In 9 cadavers, the variations were observed. In five male cadavers and in a female cadaver, the two branches of arch of aorta were the common trunk of brachiocephalic trunk and left common carotid artery and the left subclavian artery (Figure 1). In two male cadavers, the branches were four including the origin of left vertebral artery from arch of aorta (Figure 2). In a female cadaver, the three branches of arch of aorta were as follows: common trunk of brachiocephalic trunk and left common carotid artery, the left vertebral artery and the left subclavian artery.

Figure 1. Two branches of arch of aorta: common trunk of brachiocephalic trunk and left common carotid artery, left subclavian artery.

Figure 2. Four branches of arch of aorta: brachiocephalic trunk left common carotid artery, left vertebral artery, left subclavian artery.

In this cadaver, the left vertebral artery was arising by two limbs: one limb from the arch of aorta and the other limb from the descending thoracic aorta. Both limbs joined and entered the foramen transversarium of C6 (Figure 3).

Figure 3. Three branches of arch of aorta: common trunk of brachiocephalic trunk and left common carotid artery, left vertebral artery, left subclavian artery. Left vertebral artery arising by two limbs- one limb from the arch of aorta and the other limb from the descending thoracic aorta.

4. Discussion

In the present study, the normal branching pattern of the arch of aorta was observed in 82% and in 18% of cases, the aortic arch showed variations. The normal three-branch pattern of the arch of aorta is found with an incidence of 64.9–94.3% according to the literature. [1-4]

Table 1. Incidence of arch of aorta with two branches- A common trunk of brachiocephalic and left common carotid artery and left subclavian artery in different populations.

| Author            | Population   | Number of specimens | percentage |
|-------------------|--------------|----------------------|------------|
| Nelson and Sparks | Japanese     | 193                  | 1.0        |
| Satyapal et al    | South African| 320                  | 3.4        |
| Moskowitz and Topaz | American    | 1480                 | 3.2        |
| Makhanya et al    | South African| 60                   | 28.3       |
| Natsis et al      | Greek        | 633                  | 15.0       |
| Ongen’o et al     | Kenyan       | 113                  | 25.7       |
| Bhattacharai and Poudel | Nepalese | 85                   | 12.9       |
| Present study     | Indian       | 50                   | 12          |

The most common variation of the aortic arch with two branches which is also called as bovine arch- common trunk of brachiocephalic and left common carotid artery and the left subclavian artery is found with an incidence of 10–22%. [5-8] However, it is a misnomer because the arch of aorta of the cattle has only one branch that branches into right subclavian artery, a common trunk for common carotid arteries and left subclavian artery.[6] Developmentally, the two-branch pattern of the arch of aorta may be explained as follows. Aortic sac normally bifurcates into left and right limbs. Left limb of aortic sac forms the part of arch that intervenes between the origin of brachiocephalic trunk and left common carotid artery. If the aortic sac fails to bifurcate, then the left common carotid artery will connect to aortic sac directly, resulting in bicarotid trunk or common trunk giving origin to brachiocephalic trunk and left common carotid artery as observed in 12% cases in our study. [4-5] The incidence of this variation in various populations in different studies is summarized in table 1.
Origin of the left vertebral artery from the arch of aorta is between 2.4 and 8% and in the present study, this incidence was 6%. [15] The most frequent location is between the left common carotid artery and the left subclavian artery. [3] Embryologically, the left vertebral artery from the arch of aorta is due to the persistent sixth cervical intersegmental artery. [4] Satti et al. added that patients with such anomalies should be screened for coexisting aneurysms. [16] The incidence of left vertebral artery from the arch of aorta from various studies is summarized in Table 2.

| Author            | Incidence [%] |
|-------------------|---------------|
| Beatt [17]        | 5.2           |
| Mori [18]         | 6.9           |
| Stein et al [19]  | 6.0           |
| Argenomo et al [20]| 6.8           |
| Nizanowski et al [21]| 3.1         |
| Vorster et al [22]| 5.0           |
| Cavadar and Arisan [23]| 8.3       |
| Komiyana et al [24]| 2.4           |
| Panicker et al [25]| 5.0           |
| Yamaki et al [26] | 5.8           |
| Imre et al [27]   | 2.5           |
| Present study     | 6.0           |

Karacan A et al evaluated the anatomical variations of aortic arch branching with computed tomographic angiography in 1000 patients and found 20.8% had variations: type I: normal aortic arch branching pattern (79.2%), type II: brachiocephalic and left common carotid arteries arising from the aortic arch in a common trunk (14.1%), type III: left vertebral artery originating from the aortic arch (4.1%), type IV: coexistence of type 2 and type 3(1.2%), type V: aberrant right subclavian artery (0.6%), type VI: coexistence of aberrant right subclavian artery and bicarotid trunk(0.7%) and type VII: thyroidea ima artery arising from the aortic arch (0.1%). [28]

In the present study, the incidence of type 1 is 82% and type II is 12% and type III is 6% and type IV is 2%. Komiyana et al reported that two patients had dual origin of left vertebral artery with one leg originating from the aorta and another leg from the left subclavian artery. [24] Satti et al also reported the left vertebral artery with two limbs, one originating from aortic arch and other from the left subclavian artery in digital subtraction angiography.[16] When a duplicated vertebral artery is identified, it is important for the endovascular interventionist and the diagnostic radiologist to consider the possibility of an associated injury.[29] But as in the present study, the origin of left vertebral artery by two limbs with one limb from the arch of aorta and the other limb from the descending thoracic aorta is rarely reported.

5. Conclusion

Knowledge of the normal and variant anatomy of the great vessels of the neck is important for endovascular interventionists and diagnostic radiologists, more so in the era of stent placements in the carotid and vertebral arteries and new therapeutic options for intracranial interventions. A left or longer brachiocephalic trunk that also inclines to the left may extend in front of the trachea above the sternum which can cause their injury during tracheostomy, thyroid resection, laryngeal transplantation, mediastinoscopy etc.

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Conflict of Interest

The authors declare that they have no competing interests.

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