

## Variation in the Branching Pattern of the Aortic Arch: A Case Report

Mitrofanova M and Valchkevich Dzmitry\*

Department of Normal Anatomy, Grodno State Medical University, Grodno, Belarus

\*Corresponding Author: Valchkevich Dzmitry, Associate Professor, Normal Anatomy Department, Grodno State Medical University, Grodno, Belarus.

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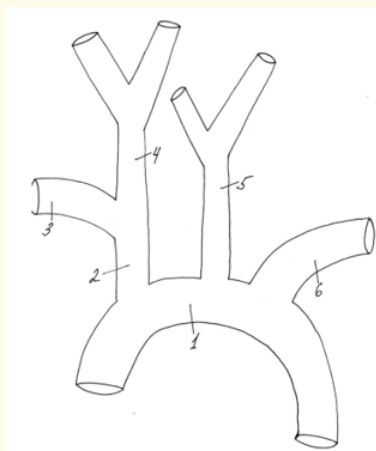
### Abstract

Variations of the branches of the aortic arch are due to alteration in the development of certain branchial arch arteries during the embryonic period. Knowledge of these variations is important during aortic, thoracic, and neck surgeries. In the present study, we tried to investigate the branching of the aortic arch on the corpses, which are in the Department of Normal anatomy, as well as to collect the most often occurring variants of branching of the aortic arch described in the literature. In ten (90.1%) cadavers, the aortic arch showed a classical branching pattern, which includes brachiocephalic trunk, left common carotid artery, and left subclavian artery. In one (9.9%) cadaver, it showed variation in the branching pattern, which includes the right common carotid artery, left common carotid, left subclavian and right subclavian.

**Keywords:** Variation; Aortic Arch; Anatomy

### Introduction

The most common aortic arch branching patterns are three main branches, namely brachiocephalic trunk (BCT), left common carotid (LCCA), and left subclavian (LSA) (Figure 1), from the right to the left [1,2].



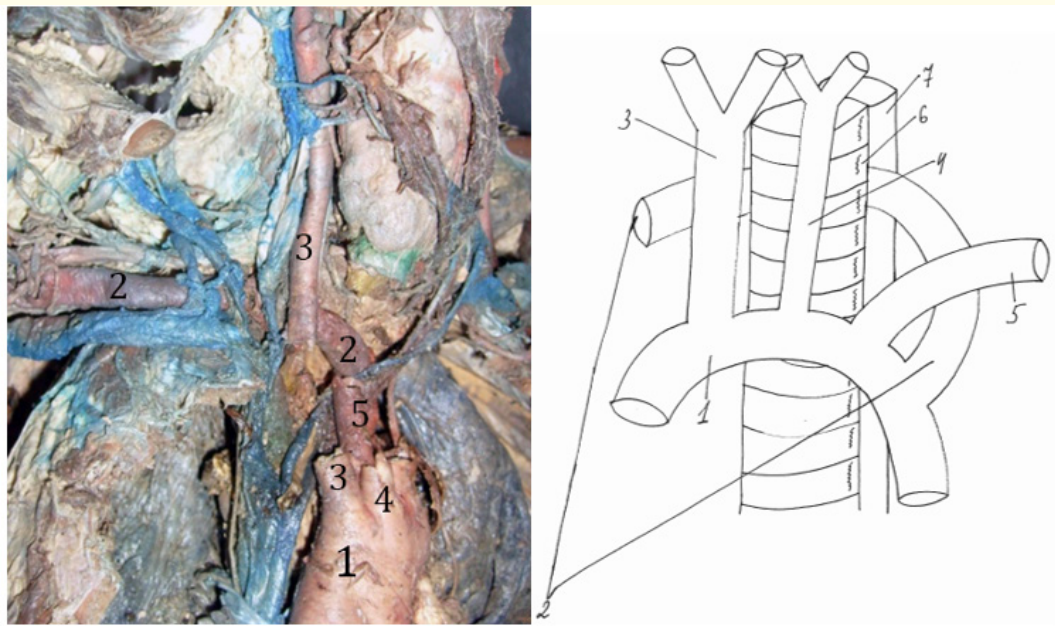
**Figure 1:** Typical ramification of aortic arch: 1 - aortic arch; 2 - BCT; 3 - a. subclavia dextra (RSA); 4 - a. carotis communis dextra (RCCA); 5 - LCCA; 6 - LSA.

The aortic arch is continuation of the ascending aorta. It starts just behind the right sternocostal articulation. Initially, going up, the aortic arch bends to the left and posteriorly, and then turns down and goes into the descending part of the aorta. From the aortic arch, BCT departs first, and then the LCCA, which starts from the middle of the aortic arch, located closer to the brachiocephalic trunk. The left subclavian artery is the last branch of the aortic arch and is usually at a distance of 1 - 1.5 cm from the LCCA.

**Case Report**

During routine anatomical dissection of male cadaver aged around 70 years at the Human Anatomy Department undertaken for education and research purposes, an anatomical variation of the ramification of the aortic arch was observed. By means of typical methods of anatomic dissection and preparation the aortic arch with its branches were dissected and cleaned.

It was found that the aortic arch has a diameter of  $34.5 \pm 1.1$  mm at the beginning and  $25.75 \pm 1.3$  mm at the its end. The following branches of arch depart from right to left: right common carotid artery, left common carotid, left subclavian, right subclavian. The RSA departs just behind the left subclavian artery at a distance of 10 mm. Then it turns right and passes between the trachea and the esophagus, bending the esophagus at a distance of 41 mm from its beginning (Figure 2a and 2b).



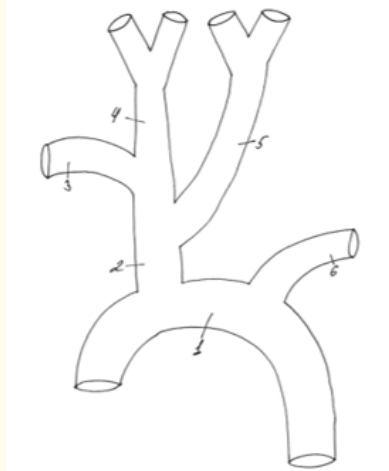
**Figure 2:** Typical ramification of aortic arch (a - macropreparation, b - scheme): 1 - aortic arch; 2 - RSA; 3 - RCCA; 4 - LCCA; 5 - LSA; 6 - trachea; 7 - esophagus.

**Discussion**

Most of the anomalies of the arch of the aorta and its branches are because of an altered development of primitive aortic arches of the embryo during the early gestation period [3]. Understanding the great vessels of the aortic arch and their variations is important for both endovascular interventionists and diagnostic radiologists. Increasing activity in the fields of cardiac and vascular surgery has revived interest in the developmental anatomy, including the aortic arch and its derivatives [4].

An understanding of the variability of these arteries remains most important in angiography and surgical procedures where an incomplete knowledge of anatomy can lead to serious implications [2].

Under M Rojas [5], in 11.43% of cases the aortic arch gives of two branches: brachiocephalic trunk together with the left common carotid artery (carotid-brachiocephalic trunk) and left subclavian artery (Figure 3).

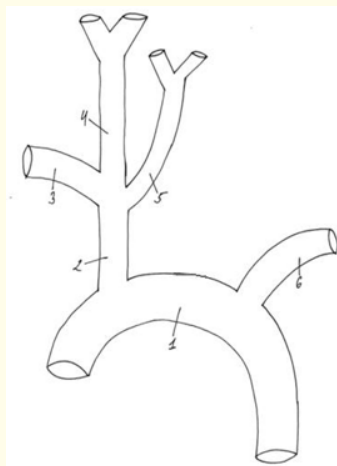


**Figure 3:** Atypical ramification of aortic arch: 1 - aortic arch; 2 - truncus carotico-brachiocephalicus; 3 - RSA; 4 - RCCA; 5 - LCCA; 6 - LSA.

Terentyev GV (1964) in all cases of finding same branching of arch have indicated that the LCCA was located in front of the left subclavian artery. In this case, the author have noted aneurysmal widening of the ascending aorta distal to BCT.

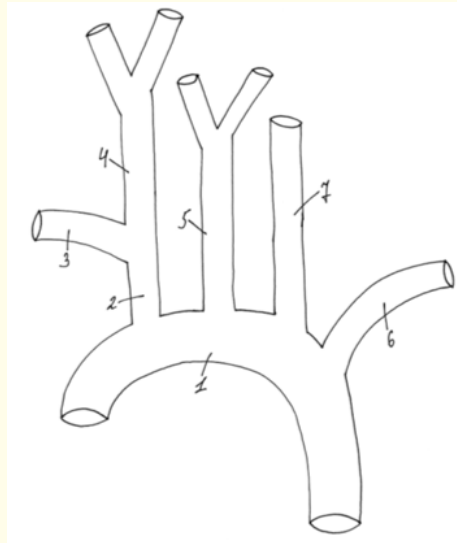
In the study of J Dumfarth it was shown that the arising of the carotid-brachiocephalic trunk and left subclavian artery was the most common atypical variant of branching pattern of aortic arch [1].

According to AM Ochkurenko, in every tenth case the BCT (with the length 0.5 - 1.7 cm) raised from the aortic arch with the LCCA [6] (Figure 4).

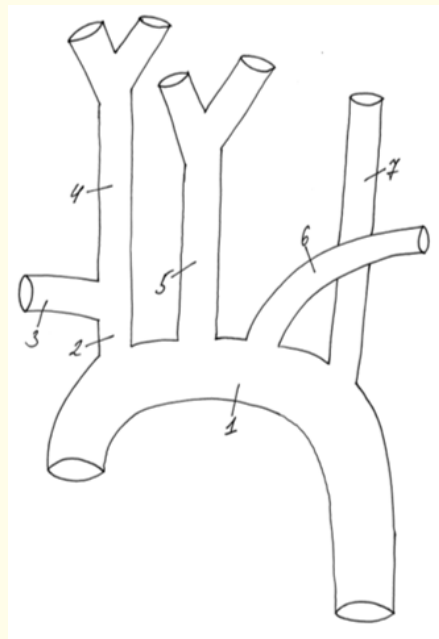


**Figure 4:** Atypical ramification of aortic arch: 1 - aortic arch; 2 - truncus carotico-brachiocephalicus; 3 - RSA; 4 - RCCA; 5 - LCCA; 6 - LSA.

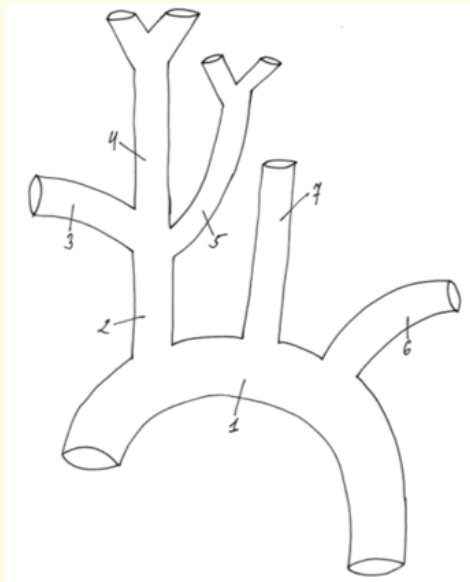
The rarer variant of aortic arch branching pattern described in the literature is arising of the vertebral arteries from the arch. The left vertebral artery (LVA) departs from the arch in 1.7% [7] to 4.8% [8] and even 6.3% [1], where the LVA goes from the aortic arch between the LCCA and LSA in 97.1% (Figure 5), in 2.3% it is to the left of LSA (Figure 6). In rest 0.6% the left vertebral artery passed between carotico-brachiocephalic trunk and left subclavian artery (Figure 7).



**Figure 5:** Atypical ramification of aortic arch: 1 - aortic arch; 2 - BCT; 3 - RSA; 4 - RCCA; 5 - LCCA; 6 - LSA; 7 - LVA.

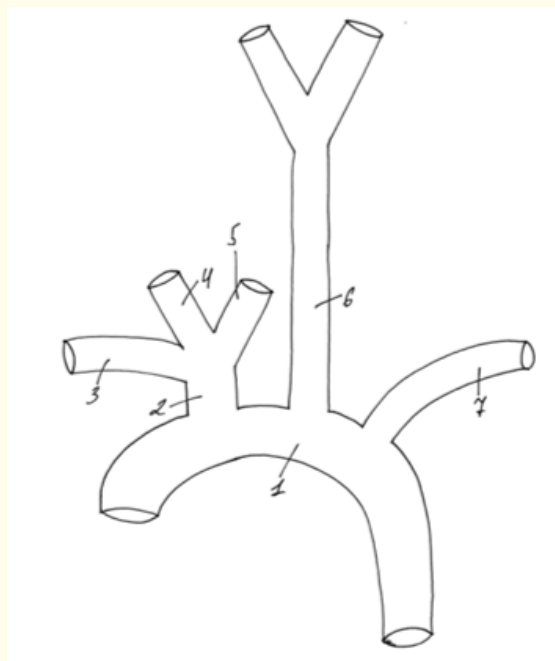


**Figure 6:** Atypical ramification of aortic arch: 1 - arcus aortae; 2 - BCT; 3 - RSA; 4 - RCCA; 5 - LCCA; 6 - LSA; 7 - LVA.



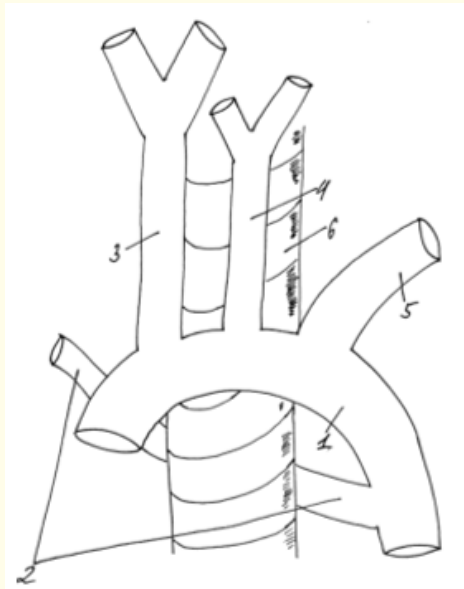
**Figure 7:** Atypical ramification of aortic arch: 1 - arcus aortae; 2 - truncus caroticobrachiocephalicus; 3 - RSA; 4 - RCCA; 5 - LCCA; 6 - LSA; 7 - LVA.

There is literature data, when the right internal (RICA) and external (RECA) carotid arteries can start from the brachiocephalic trunk [8,9] (Figure 8).

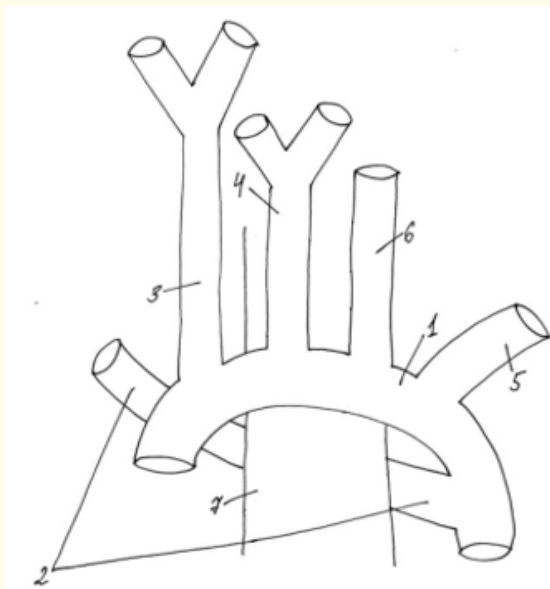


**Figure 8:** Atypical ramification of aortic arch: 1 - arcus aortae; 2 - BCT; 3 - RSA; 4 - RECA; 5 - RIA; 6 - LCCA; 7 - LSA.

One of the first anatomical studies devoted to variation of branching pattern of the aortic arch, carried out on a large material (300 corpses), was the study of RL Herzenberg (1930). He described 36 variations of atypical branching of the arch. Thus, he found the following branches raised from the aortic arch: right and left common carotid arteries and left subclavian arteries (in 1.9%). The RSA took origin from descending aorta (Figure 9) and went from left to right between the trachea and esophagus.

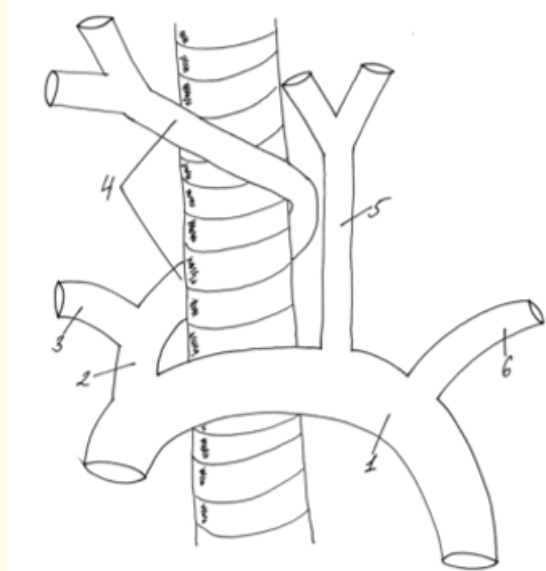


**Figure 9:** Atypical ramification of aortic arch: 1 - aortic arch; 2 - RSA; 3 - RCCA; 4 - LCCA; 5 - LSA; 6 - trachea.



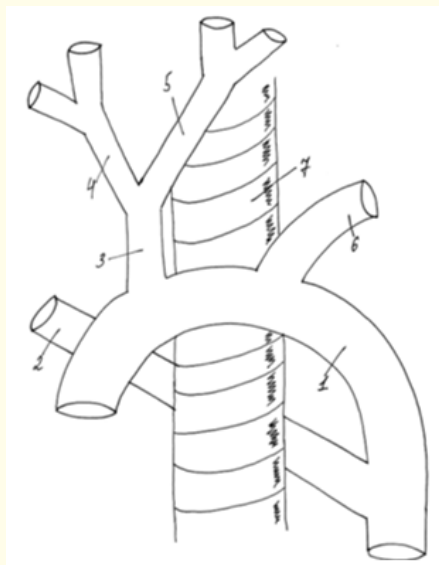
**Figure 10:** Atypical ramification of aortic arch: 1 - aortic arch; 2 - RSA; 3 - RCCA; 4 - LCCA; 5 - LSA; 6 - LVA; 7 - oesophagus.

The following variation of topography is a particular danger for surgery, where the right common carotid artery forms a loop around the trachea, which can provoke clinical complications (Figure 11).



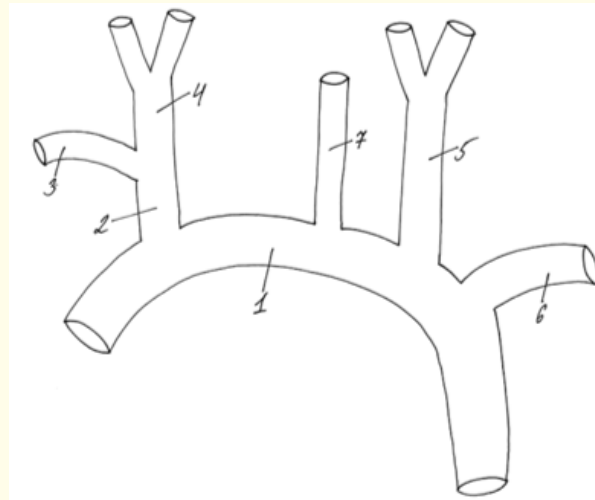
**Figure 11:** Atypical ramification of aortic arch: 1 - aortic arch; 2 - BCT; 3 - RSA; 4 - RCCA; 5 - LCCA; 6 - LSA; 7 - trachea.

According to Y Qiu, there are several cases where both common carotid arteries diverged by a common trunk, and the right subclavian artery was the third branch of the aortic arch, passing posterior to the trachea [9] (Figure 12).



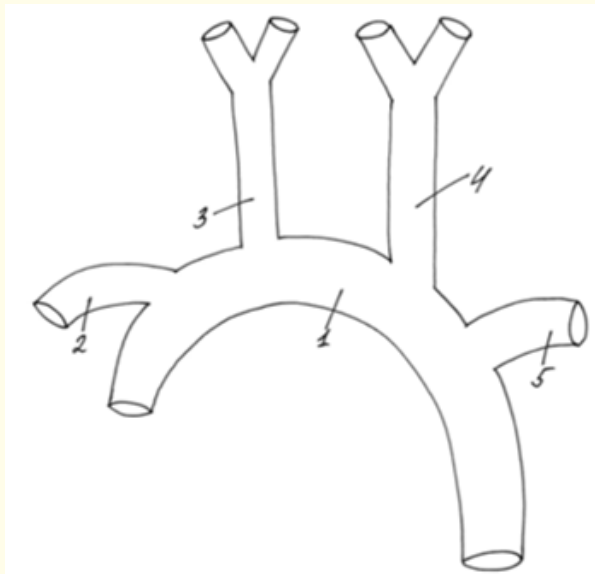
**Figure 12:** Atypical ramification of aortic arch: 1 - aortic arch; 2 - RSA; 3 - truncus carotis communis; 4 - RCCA; 5 - LCCA; 6 - LSA; 7 - trachea.

Other interesting variants of aortic arch branching, which should be taken into account in surgical manipulations on the neck and chest, have been described in the literature. It was found that the aortic arch can give off the unpaired thyroid artery [5,10,11]. However, this artery is always passed between the brachiocephalic trunk and left common carotid artery (Figure 13).



**Figure 13:** Atypical ramification of aortic arch: 1 - aortic arch; 2 - BCT; 3 - RSA; 4 - RCCA; 5 - LCCA; 6 - LSA; 7 - a. thyroidea ima.

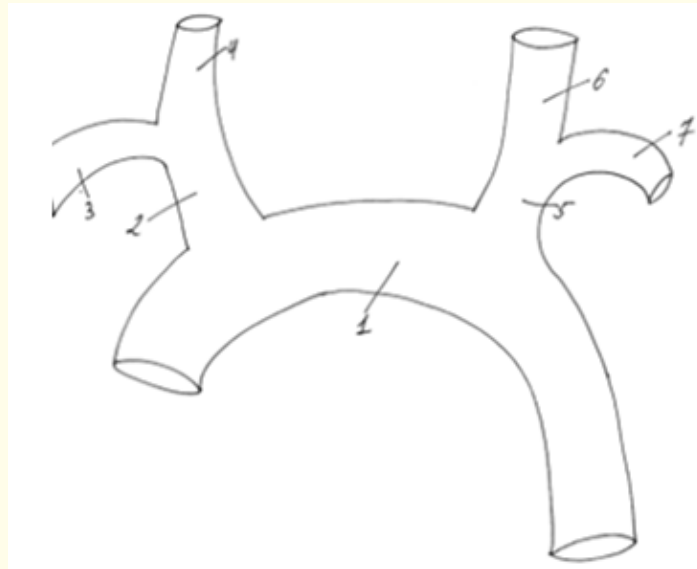
There are cases of complete absence of brachiocephalic trunk, and in this case both right and left common carotid and both subclavian arteries start from the aortic arch directly [12] (Figure 14).



**Figure 14:** Atypical ramification of aortic arch: 1 - aortic arch; 2 - RSA; 3 - RCCA; 4 - LCCA; 5 - LSA.

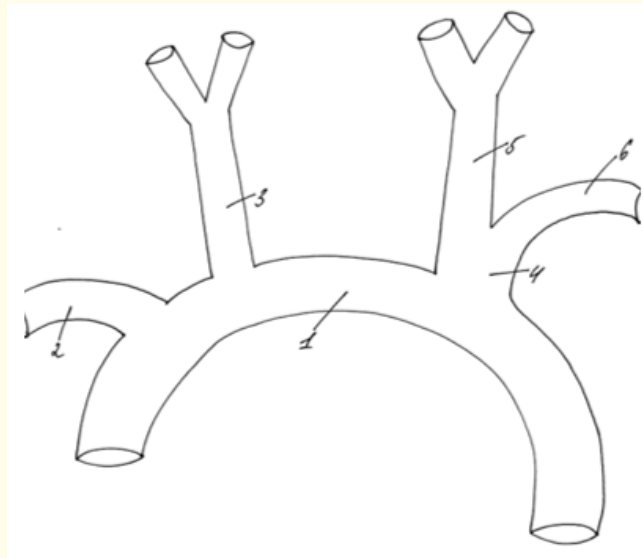


In some individuals, it can meet paired symmetrical brachiocephalic trunk [10,13] (Figure 15).



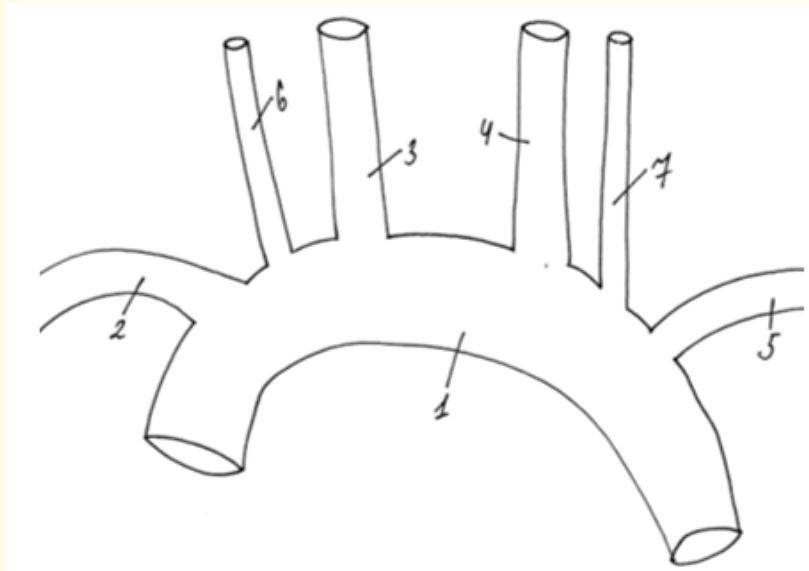
**Figure 15:** Atypical ramification of aortic arch: 1 - aortic arch; 2 - right BCT; 3 - RSA; 4 - RCCA; 5 - left BCT; 6 - LCCA; 7 - LSA.

Right aortic arch (a rare anatomical variant in which the aortic arch is on the right side rather than on the left, figure 16) has been studied by numerous investigators and can be met less than in 1% [10,14,15,16].



**Figure 16:** Right aortic arch: 1 - aortic arch; 2 - RSA; 3 - RCCA; 4 - BCT; 5 - LCCA; 6 - LSA.

Cases of six branches of aortic arch can be met in 0.9% to 5.2% [17] (Figure 17).



**Figure 17:** Atypical ramification of aortic arch: 1 - aortic arch; 2 - RSA; 3 - RCCA; 4 - LCCA; 5 - LSA; 6 - RVA; 7 - LVA.

## Conclusion

Despite the fact that the variations of aortic arch branching pattern are usually asymptomatic, recognition of that variations is important because they may cause symptoms due to tracheoesophageal compression or complications during surgical or endovascular interventional procedures of the aorta and its branches. Furthermore, these variations may be accompanied by other congenital abnormalities.

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