Brief Report

Anatomical Variations in Aortic Arch Branching Pattern

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Abstract

Background: The branch anatomy of the aortic arch varies widely between individuals. These are likely due to alterations in the development of aortic arch arteries during the embryonic period. The purpose of this study is to determine the frequency of the aortic arch branch variations in the local population and provide useful data to intervention radiologists, neck and thoracic surgeons.

Methods: In this study, branching pattern of the aortic arch in 226 patients was retrospectively evaluated by MR angiography. MRA performed on a high field 3 Tesla MRI scanner using 3D flash sequence.

Results: The normal aortic arch branching pattern was observed in 192 patients (84.9%). Also, three variations of the aortic arch branching pattern were observed. The aortic arch in 12.4% of the patients had two arterial branches. In 0.9% of cases, the left vertebral artery originated directly from the aortic arch. In 1.8% of cases, the right subclavian artery originated as the fourth aortic arch branch.

Conclusion: Although the number of cases with aortic arch branches variation in our study is similar to other studies, the Bovine aortic arch variation is more common than other variations of aortic arch branches.

Keywords: Aortic arch, brachiocephalic trunk, magnetic resonance angiography

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Introduction

The most common aortic arch branching patterns are three main branches, namely brachiocephalic, left common carotid, and left subclavian, from the right to the left. Other branching patterns are formed due to the increased or decreased number of branches and their formation.[1] In some cases, there are two aortic arch branches. The first branch includes the common trunk of right subclavian, right common carotid and the left common carotid arteries. The second branch is related to the left subclavian artery. This aortic arch branching pattern is called Bovine aortic arch.[2] Some variations of the aortic arch branches are rare, such as the branching of the retroesophageal right subclavian artery as the last branch of the aortic arch.[3] Identification of variations in the branching pattern of the aortic arch and the frequency of each branching in every population is very important for thoracic and neck surgery.

Patients and Methods

A retrospective study was performed on 226 adult patients (116 males and 110 females) with MRA of neck vessels in the Department of Radiology at Khatam-al-Anbia Hospital, Tehran, Iran. The study period was from October 2013 to June 2014.

Inclusion Criteria

Patients in all ages and both genders who have an MRA of neck vessels in the Department of Radiology at Khatam-al-Anbia Hospital, between October 2013 to June 2014, were included in this study.

Exclusion Criteria

- The patients who have claustrophobia.
- Those patients with surgeries involving aortic arch branches.

In this study, MRA was performed on a high field 3 Tesla MRI scanner (Siemens MAGNETOM Trio) using 3D Flash (Fl3D) sequence with the following parameters: A 22 × 25 cm FOV coronal view, 80 sections that were 1.4 mm thick, a repetition time of 3 ms, and an echo time of 1 ms. For a better view of the neck vessels, 20 ml of gadolinium was administered. The raw images were processed using maximum intensity projection (MIP) algorithm.

Results

According to images from 226 patients, 84.9% of patients had a normal branching pattern of the aortic arch (Type A). In addition to the normal case, three other variations of the aortic arch branching pattern were observed (Figure 1).

In 0.9% of cases, the left vertebral artery originated between left common carotid artery and left subclavian artery. After branching from the aortic arch, the left vertebral artery has entered the transverse foramen of the sixth cervical vertebra and continued its normal course (Type B). The aortic arch in 12.4% of the patients had two arterial branches (Type C). In 1.8% of cases, the right subclavian artery arises as the fourth aortic arch branch (Type D) and passes through the retroesophageal course to the right upper extremity (Table 1).

Discussion

Some researchers believe that the abnormal origin and course

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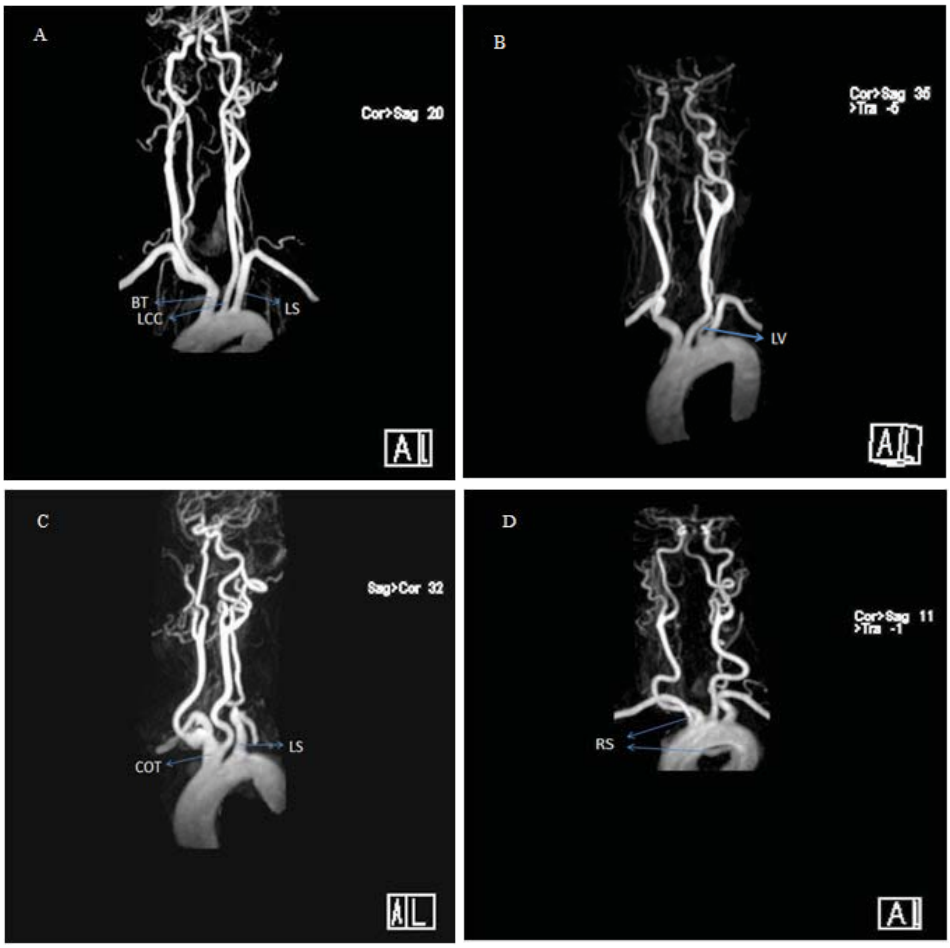

Figure 1. MRA images of cervical vessels. **A)** normal branching pattern show the brachiocephalic trunk (BT), left common carotid artery (LCC) and left subclavian artery (LS); **B)** Variation of the left vertebral artery (LV) originated from the aortic arch; **C)** Bovine aortic arch variation. COT: common trunk; LS: left subclavian artery; **D)** the retroesophageal right subclavian artery (RS) as the last branch of the aortic arch.

Table 1. Percentage frequency of various types of aortic arch branching pattern in our study

Variation type	Number of individuals	Frequency
Type A	192	84.9%
Type B	2	0.9%
Type C	28	12.4%
Type D	4	1.8%

of an artery may favor cerebral disorders.[4] Therefore, awareness of abnormal branches originating from aortic arch is important in diagnosis of hemodynamic disorders and intracranial aneurysm.

Embryological basis

Investigating the formation of aortic arch and its branches during the embryonic period is essential for explaining its variations. Over this period, six aortic arches arise from aortic sac and the distal part of the truncus arteriosus. The fifth arch has not been completely formed, and some arches are lost during different stages of the fetal development. The loss of different parts of aortic arches of the both sides ultimately leads to the formation of the main vascular pattern.[5] The aortic arch is formed by the left fourth arch. The right subclavian artery arises from the right fourth aortic arch, right dorsal aorta, and right seventh intersegmental artery. The right common carotid artery is formed by the right third aortic arch, and the left common carotid artery is formed by the left third aortic arch. The subclavian artery arises from the left seventh intersegmental artery. Any changes in the embryonic formation pattern cause arterial variations.[6] Embryologically, the abnormal origin of the left vertebral artery of the aortic arch is due to the remaining parts of the sixth intersegmental arteries. The branching of the right subclavian artery, as the fourth aortic branch, occurs when the artery is formed by the right distal dorsal aorta and the fourth intersegmental artery. In this case, the proximal part of the right dorsal aorta and the right fourth aortic arch are lost. Variation in the branching pattern of double-trunk from the aortic arch occurs due to the connection of proximal part of the left third aortic arch to the right branch of aortic sac.[5]

There are some studies regarding the aortic arch branching pattern in different areas of the human corpse.[7] Based on a study in Korea, almost 84% of the patients have a normal branching pattern and 8% of them had arterial double-trunk. In 8% of cases, left vertebral branching from the aortic arch has been reported.[8]

In a study in 2006 by Nayak on 62 human cadavers in India, 94% of the patients had a normal aortic branching pattern, and 4.8% of them had a common origin for carotid arteries. Doubled-trunk branching and the right subclavian branching from aortic arch were observed in 1.6% of cases. In their study, the left vertebral artery branching from the aortic arch was reported in 1.6% of cases.[9]

In the present study, branching pattern of the aortic arch in adult patients was evaluated by 3-Tesla MR angiography, as a non-aggressive method. Relatively higher percentage of Bovine aortic arch branching variation in this study is a notable finding. In a study, Malone, et al. show a significant relationship between Bovine aortic arch variation and aortic aneurysm in older patients.[10]

As a result of our findings, although the number of cases with variation in aortic arch branches in this study is similar to other studies, the Bovine aortic arch is more common than other variations of aortic arch branches. Paying attention to those variations and determining the prevalence of each aortic arch branching pattern in a given population is very important for clinical examinations, as well as neck and thoracic surgeries.

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