Evaluation of anatomical variations in aortic arch branching pattern in south Indian population using computed tomography

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Abstract

**Background and Purpose:** Anatomical variations can occur in the aortic arch branching pattern and the frequency of various types vary in different population groups. These are likely due to alterations in the development of aortic arch arteries during embryonic period. These variations are significant for diagnostic and surgical procedures in head and neck. The purpose of this study is to determine the frequency of the aortic arch branch variations on CT in the local population and thus provide useful data to intervention radiologists, vascular, head and neck and thoracic surgeons.

**Materials and Methods:** CT scans of the chest of a total of 306 patients performed in our hospital were analyzed retrospectively and assessed for the origin of the major aortic branches. Axial images are primarily used for assessment. Thereafter necessary reformatted multiplanar and curved reformatted images, MIP, VR images were used to assign each patient is assigned into a particular type of the branch variation.

**Results:** The most common aortic arch branching pattern - type 1 was found in 274 of 306 cases (89.5%). In this pattern three major branches - Brachiocephalic trunk (BT), Left common carotid (LCC) and Left subclavian (LS) originated independently from the arch of aorta. Second commonest branching pattern was type 2 which was found in 16 of 306 cases (5.2%). This pattern had only two branches - The first was a common trunk designated as great trunk (GT) which gave the brachiocephalic trunk and left common carotid artery. The other was the left subclavian artery. Third common branching pattern was type 3 which was seen in 14 of 306 cases (4.6%), which had four branches: Brachiocephalic trunk, left common carotid artery, left subclavian artery and left vertebral artery (LV). Two rare variants were found, 1 case each (0.3%). One had four branches: right common carotid, left common carotid, left subclavian and aberrant right subclavian artery (ARSC). This has been called the type 4 variant. The other had three branches: great trunk, left vertebral artery and left subclavian artery (type 6 variant).

**Keywords:** BT- Brachiocephalic trunk, LCC- Left common carotid artery, RCC – Right common carotid artery, LS- Left subclavian artery, LV- Left vertebral artery, GT- Great trunk, ARSC- Aberrant right subclavian artery

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Received Date: 17/08/2014  Accepted Date: 27/08/2014

INTRODUCTION

Aorta arises from the left ventricular outlet tract. Arch of aorta is located in the superior mediastinum. A total of six pairs of aortic arches connect the ventral aortic sac with the paired dorsal aortae in the embryonic life. Later the aortic arches are reduced in number and extensively transformed and during this process, anatomical variations in aortic arch can occur¹. Aortic arch usually gives rise to three branches - Brachiocephalic trunk (BT), left common carotid (LCC) and left subclavian artery (LS). BT usually originates to the right of midvertebral line and LCC and LS to the left. These branches may arise from ascending aorta or the beginning of the arch. There may be varying distance between the branches. Variations are also noted in the number of branches arising from arch of aorta ¹. Variations in the branching pattern of arch of aorta have been studied in different populations and it is noted to significantly differ in different racial populations². Lot of newer techniques
have been developed in the field of cardiac and vascular surgery. It is very important for the surgeon or interventionist to identify these variations in patients undergoing angiography, aortic instrumentation and head and neck surgery. Therefore it is essential to know the variations in branching pattern of aortic arch in local population.

AIMS OF THE STUDY
The purpose of this study is to determine the frequency of the variations in aortic arch branching pattern in our local population.

Settings and design of study
This is a retrospective study done on 306 patients who have undergone contrast enhanced CT of chest in the Department of Radio Diagnosis at Father Muller Medical College Hospital, Mangalore. The study period was 6 months from August 2013 to January 2014.

Inclusion Criteria
All patients of all ages and both sexes who underwent contrast enhanced CT of thorax in the Department of Radio Diagnosis at Father Muller Medical College Hospital between August 2013 to January 2014 were included in the study.

Exclusion Criteria
- All the patients whose contrast enhanced CT studies were not available for assessment or not technically adequate for interpretation
- Those patients with surgeries involving aortic arch branches

MATERIAL AND METHODS
All scans were done using GE Bright speed 16 –slice MDCT at 120 KVp and 300 mAs with 5mm slice thickness, 0.8 second gantry rotation. Scanning protocol consisted of contrast enhanced scans covered from the level of clavicle to the diaphragm. 90-100 ml of 350mg/ml non ionic iodinated contrast was injected using automated injector at the rate of 3-4ml/second. Bolus tracking method was used, with imaging started after adequate threshold was attained in the descending aorta. Images were retro reconstructed with 0.625 mm slice thickness. Axial images were primarily used for assessment. Thereafter necessary reformatted multiplanar and curved reformatted images, MIP, VR images were used for determining the aortic arch branches. The frequency of occurrence of different variations, as well as any new variations were noted.

STATISTICAL ANALYSIS
Collected data was analyzed for frequency of different aortic arch branching patterns.

RESULTS
CT studies of a total of 306 patients were analyzed retrospectively. 192 were males (62.7%) and 114 were females (37.3%). In our study the most common aortic arch branching pattern was type 1 which was found in 274 of 306 cases (89.5%). In this pattern, three major branches - Brachiocephalic trunk (BT), left common carotid (LCC) and left subclavian artery (LS) originated independently from the arch of aorta. Second common branching pattern was type 2, which was found in 16 (5.2%) which had only two branches - The first was a common trunk designated as great trunk (GT) which included Brachiocephalic trunk and left common carotid artery. Third common branching pattern was type 3 pattern, which was found in 14 (4.6%), which had four branches: Brachiocephalic trunk, left common carotid artery, left subclavian artery and left vertebral artery (LV). Two rare variants were found, 1 case each (0.3%). One had four branches: right common carotid, left common carotid, left subclavian and aberrant right subclavian artery (ARSC). This has been called type 4. ARSC was the last branch of aortic arch. Other rare variant had three branches: great trunk, left vertebral artery and left subclavian artery. This has been called as type 6 variant.

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

<table>
<thead>
<tr>
<th>Type</th>
<th>Number of individuals</th>
<th>Frequency</th>
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<tbody>
<tr>
<td>1</td>
<td>274</td>
<td>89.5 %</td>
</tr>
<tr>
<td>2</td>
<td>16</td>
<td>5.2 %</td>
</tr>
<tr>
<td>3</td>
<td>14</td>
<td>4.6 %</td>
</tr>
<tr>
<td>Others</td>
<td>2</td>
<td>0.65 %</td>
</tr>
</tbody>
</table>

Figure 1: graph showing the relative frequency of various branch patterns in our study
Table 2: Comparison between relative frequencies of occurrence of various aortic arch branching pattern in different population studies:

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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>89.5%</td>
<td>63.5%</td>
<td>83%</td>
<td>85.2%</td>
<td>74.3%</td>
<td>94.3%</td>
<td>77.3%</td>
<td>83.3%</td>
</tr>
<tr>
<td>2</td>
<td>5.2%</td>
<td>19.2%</td>
<td>15%</td>
<td>7.8%</td>
<td>14.3%</td>
<td>1.03%</td>
<td>14.6%</td>
<td>10.9%</td>
</tr>
<tr>
<td>3</td>
<td>4.6%</td>
<td>15.3%</td>
<td>0.79%</td>
<td>5.1%</td>
<td>8.5%</td>
<td>3.1%</td>
<td>8%</td>
<td>4.3%</td>
</tr>
</tbody>
</table>

South Indian | Central India | Greek | Turkish | South India | American Japanese man | Central India | Japanese |

Figure 2: curved reformatted and axial CT images show Type 1 pattern-BT, LCC, LS arising from the aortic arch.

Figure 3: curved reformatted CT images show Type 2 pattern-GT and LS arising from the aortic arch.

Figure 4: curved reformatted and axial CT images show Type 3 pattern-BT, LCC, LV and LS arising from the aortic arch.

Figure 5: curved reformatted and axial CT images show Type 4 pattern-RCC, LCC, LS and ARSC arising from the aortic arch.

DISCUSSION

Aortic arch usually gives three branches, brachiocephalic trunk (BT), left common carotid (LCC) and left subclavian artery (LS). This pattern was seen in 89.5% of individuals in our study. Variation from this normal pattern was seen 10.5% of the individuals. Type 1 variation of the aortic arch is the “normal” aortic arch and it is found with frequency ranging from 64.9 to 94.3% according to the literature and is higher than any other type\(^\text{2,4,5,6,7}\). In our study the frequency of this type (89.5%) was within the range of frequencies seen in other studies. Type 2 variation is the second most common variation and its frequency ranges in various studies from 11 to 27%\(^\text{2}\). Only Nelson and Sparks have reported this type as third most common in American–Japanese men, with frequency of 1.03%\(^\text{7}\). Nizankowski et al. have got
Anatomic variations in aortic arch branching pattern varies in population to population. It is very important to know these variations as it has a lot of clinical implications. Especially it is important for cardiothoracic surgeons, head and neck surgeons and interventional radiologist to know these variations preoperatively to prevent some of the postsurgical complications which can arise from them.

REFERENCES


Source of Support: None Declared
Conflict of Interest: None Declared