Research Article

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

Ram Shenoy Basti[1*], Sanjay Kumar[2]

[1]Assistant Professor, [2]Junior Resident, Department of Radio diagnosis, Father Muller Medical College, Mangalore, Karnataka, INDIA.
Email: rshenoydr@gmail.com

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

***Address for Correspondence:**
Dr Ram Shenoy Basti, Assistant Professor, Department of Radiodiagnosis, Father Muller Medical College, Mangalore, Karnataka, INDIA.
Email: rshenoydr@gmail.com
Received Date: 17/09/2018 Accepted Date: 27/10/2018

Access this article online	
Quick Response Code:	Website: www.statperson.com
	Volume 8 Issue 4

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 occur[1]. 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 populations[2]. Lot of newer techniques

How to site this article: Ram Shenoy Basti, Sanjay Kumar. Evaluation of anatomical variations in aortic arch branching pattern in south Indian population using computed tomography. *International Journal of Recent Trends in Science and Technology* October to December 2018; 8(4): 11-15 http://www.statperson.com

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 [2,3,4]. 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 2018.

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 2018 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.

STASTICAL 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[19].

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

Type	Number of individuals	Frequency
1	274	89.5 %
2	16	5.2 %
3	14	4.6 %
Others	2	0.65 %

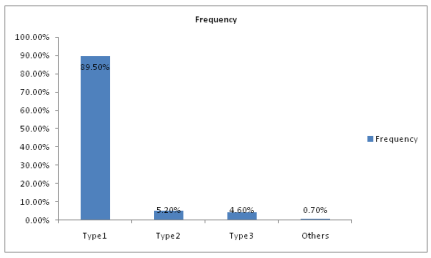

Figure 1: graph showing the relative frequency of various branch patterns in our study

Table 2: Comparison between relative frquencies of occurance of various aortic arch branching pattern in different population studies:

Type	Present study	Budhiraja *et al* (1)	Nastis *et al* (2)	Ergun *et al* (4)	Nayak *et al* (6)	Nelson *et al* (7)	Patil *et al* (11)	Adachi *et al* (18)
1	89.5%	63.5%	83%	85.2%	74.3%	94.3%	77.3%	83.3%
2	5.2%	19.2%	15%	7.8%	14.3%	1.03%	14.6%	10.9%
3	4.6%	15.3%	0.79%	5.1%	8.5%	3.1%	8%	4.3%
	South Indian	Central India	Greek	Turkish	South India	American Japanese man	Central India	Japanese

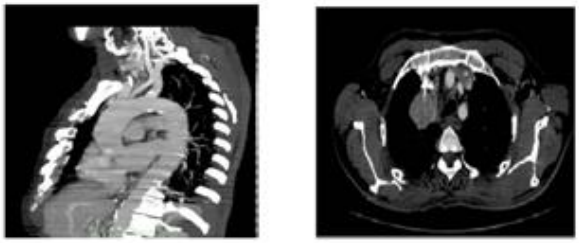

Figure 2: curved reformatted and axial CT images show Type 1 pattern-BT, LCC, LS arising from the aortic arch.

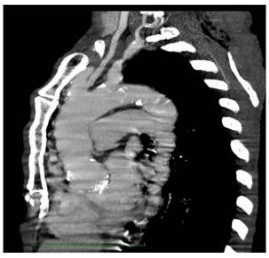

Figure 3: curved reformatted CT images show Type 2 pattern-GT and LS arising from the aortic arch.

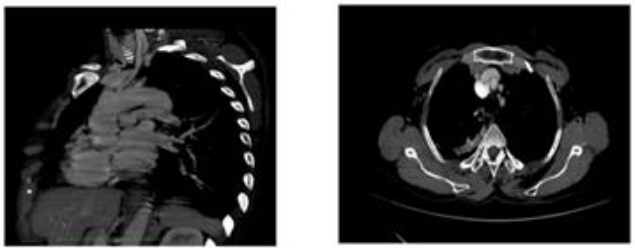

Figure 4: curved reformatted and axial CT images show Type 3 pattern-BT, LCC, LV and LS arising from the aortic arch.

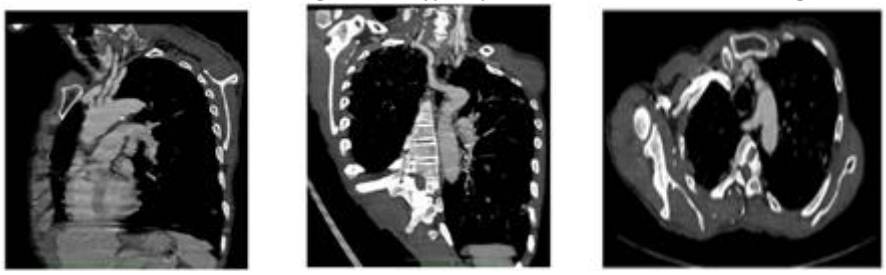

Figure 5: curved reformatted and axial CT images show Type 4 pattern-RCC, LCC, LS and ARSC arising from the aortic arch.

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[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% [2]. Only Nelson and Sparks have reported this type as third most common in American–Japanese men, with frequency of 1.03% [7]. Nizankowski *et al.* have got

even lower frequency of 0.9% in a Polish population[8]. In our study 16 individuals (5.2%) had this variation, which is much lower compared to frequencies in most of the studies. This pattern was also called "bovine aortic arch" which is a misnomer as it does not actually resemble the arch pattern of a cattle[9]. Clinical symptoms related to this pattern are attributed to mediastinal widening[10]. Failure to recognize this pattern may result in fatal consequences at surgery. There is also increased incidence of cerebrovascular disease due to alteration in hemodynamics[11]. Type 3 variation is the third most common with frequency ranging from 2.5 % to 8% by various authors[2]. Nelson and Sparks described it as second common with the frequency of 3.1% in American–Japanese men[7]. This variation was seen in 14 individuals (4.6%) in our study. These individuals are at increased risk of vertebral artery injury during anterior cervical spine surgeries resulting in permanent neurological deficits[12]. False positive diagnosis of occlusive disease of left vertebral artery may be considered if not catheterized during angiography[2]. V1 segment of vertebral artery arising directly from aortic arch are at increased risk of atherosclerosis[1]. There is also increased incidence of cerebrovascular disease due to alteration in hemodynamics[11]. Two other rare variants were also found. One had four branches: right common carotid, left common carotid, left subclavian and aberrant right subclavian artery (ARSC). This is called Type 4 variant[19]. ARSC was the last branch of aortic arch to the left side of midline. It crossed over to the right side behind the arch. ARSC is normally found in 1.4% with a wide range of frequencies from 0.13% to the high percentage of 25%[13]. ARSC usually originates from the left-side of midline as a last branch of arch. In its course to the right arm, most of the time (85%) passes behind the esophagus, therefore also called retro esophageal right subclavian[14,15]. In some instances it may run between the trachea and the esophagus, may be even in front of the trachea[17]. Even the right laryngeal nerve cannot form a loop around the RS which is termed as non recurrent laryngeal nerve[16]. Clinically it is known to cause a condition called "dysphagia lusoria" in which the patient has difficulty and pain during swallowing because of compression on the esophageal wall[14,15]. Surgical intervention is essential in such cases. Likewise it can compress on trachea and cause dyspnoea. Also it may be injured during tracheostomy[17]. Another rare variant which was seen in one case had three branches from aortic arch. Great trunk which was also seen in type 2 variant. But this variant had two more branches than one branch seen in type 2. They are left vertebral artery and left subclavian artery. This has been called type 6 variant[19]. Similar variant was also seen in one of the cases by Budhiraja *et al* and Nayak *et al*[1,6]. Since this variant is combination of type 2 and 3, so its clinical implication also is a combination of both. Various studies have been done on different populations to know the frequency of anatomical variants of aortic arch branching pattern[2]. It is found that there are three most common variants of branching pattern. Most of the other variations are rare. But it is found that the frequency of these three variants was significantly different in various population and race. Frequencies of variants of aortic arch branching pattern in various studies in comparison with our study are shown in **table 2.** Nayak *et al* had studied aortic arch variation in south India which is very similar to our population. But they had only 35 cases included in their conclusion[6].

CONCLUSION

Anatomic variations in aortic arch branching pattern varies in population to population. It is very important to know these variations as it has 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

1. Budhiraja V, Rastogi R, Jain V, Bankwar V, Raghuwanshi S. Anatomical Variations in the Branching Pattern of Human Aortic Arch: A Cadaveric Study from Central India. ISRN Anat. 2013; 2013:1–5.
2. Natsis KI, Tsitouridis IA, Didagelos MV, Fillipidis AA, Vlasis KG, Tsikaras PD. Anatomical variations in the branches of the human aortic arch in 633 angiographies: clinical significance and literature review. Surg Radiol Anat SRA. 2009 Jun; 31(5):319–23.
3. Shiva Kumar GL, PAdmidi N, Somayaji SN, Nayak S, Vollala VR. Anomalous branching pattern of the artic arch and its clinical applications. Singapore Med J. 2010; 51:e182-e183.
4. Ergun E, Şimşek B, Koşar PN, Yılmaz BK, Turgut AT. Anatomical variations in branching pattern of arcus aorta: 64-slice CTA appearance. Surg Radiol Anat. 2013 Aug 1; 35(6):503–9.
5. Grande NR, Costa e Silva A, Pereira AS, Aguas AP. Variations in the anatomical organization of the human aortic arch. A study in a Portuguese population. Bull Assoc Anat (Nancy). 1995 Mar; 79(244):19-22.
6. Nayak RS, Pai MM, Prabhu LV, D'Costa S, Shetty P. Anatomical organization of aortic arch variations in the India: embryological basis and review. J Vasc Bras. 2006 5:95–100
7. Nelson ML, Sparks CD. Unusual aortic arch variation: distal origin of common carotid arteries. Clin Anat. 2001; 14(1):62-5.
8. Nizankowski C, Rajchel Z, Ziólkowski M. Abnormal origin of arteries from the aortic arch in man. Folia Morphol (Warsz). 1975; 34(2):109-16.

9. Layton KF, Kallmes DF, Cloft HJ, Lindell EP, Cox VS. Bovine aortic arch variant in humans: clarification of a common misnomer. AJNR Am J Neuroradiol. 2006 Aug;27(7):1541-2
10. Karkoulias KP, Efremidis GK, Tsiamita MS, Trakada GP, Prodromakis EN, Nousi ED, Spiropoulos KB. Abnormal origin of the left common carotid artery by innominate artery: a case of enlargement mediastinum. Monaldi Arch Chest Dis. 2003 Jul-Sep;59(3):222-3
11. Patil ST, Meshram MM, Kamdi NY, Kasote AP, Parchand MP. Study on branching pattern of aortic arch in Indian. Anat Cell Biol. 2012 Sep; 45(3):203-6.
12. Lu J, Ebraheim NA. The vertebral artery: surgical anatomy. Orthopedics. 1999 Nov; 22(11):1081-5.
13. Bergman RA, AWW AK, Miyauchi R. Illustrated encyclopedia of human anatomic variation (online). http://www.vh.org/Providers/Textbooks/AnatomicVariants/Cardiovascular/Text/Arteries/Aorta.html.(1985–2002) pp 1–35
14. Backer CL, Ilbawi MN, Idriss FS, DeLeon SY. Vascular anomalies causing tracheoesophageal compression. Review of experience in children. J Thorac Cardiovasc Surg. 1989 May; 97(5):725-31.
15. Meher R, Sabherwal A, Singh I, Raj A Dysphagia due a to rare cause. Indian J Surg. 2004;66:300
16. Maranillo E, Vazquez T, Quer M, Niedenführ MR, Leon X, Viejo F, Parkin I, Sanudo JR. Potential structures that could be confused with a nonrecurrent inferior laryngeal nerve: an anatomic study. Laryngoscope. 2008 Jan; 118(1):56-60.
17. Chadha NK, Chiti-Batelli S. Tracheostomy reveals a rare aberrant right subclavian artery; a case report. BMC Ear Nose Throat Disord. 2004 Mar 30; 4(1):1.
18. Adachi B: Das arteriensystem der Japaner, Kyoto.Kenkyusha 1928, 1:29-41.
19. Thompson A; Third annual report of the committee of the collective investigation of the Anatomical Society of Great Britain and Ireland for the year 1891-92. J Anat Physiol. Jan 1893; 27(Pt 2): 183–194.

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