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Anatomical Variations Of Branching Of Aortic Arch On Contrast Enhanced Computed Tomography Of Thorax.

Dr. Fathima Hana M.[1] Dr. Abdul Rasheed V.P.[2] Dr. Devdas Acharya K.[3]
[1](Postgraduate, Department Of Radiodiagnosis, Yenepoya Medical College, Mangalore, Karnataka, India.)
[2](Senior Resident, Department Of Radiodiagnosis, Yenepoya Medical College, Mangalore, Karnataka, India.)
[3](Professor and Head of department, Department Of Radiodiagnosis, Yenepoya Medical College, Mangalore, Karnataka, India.)

Abstract
Background:
Congenital aortic arch malformations present a large spectrum of variations and anomalies that emanate from disordered embryogenesis of branchial arches. These aberrations are the result of either abnormal persistence or involution of embryonic vascular segments. The branching pattern of the arch aorta is important to the clinicians as an unconventional branching pattern of the arch or aorta may be the cause of the symptoms that brought the patient to the hospital; or it may be crucial to the clinician in making the plan of care for the patient. These malformations can be isolated or they may be associated with other intra cardiac and/or chromosomal defects. CT provides high spatial resolution evaluation of vascular anomalies and can be reformatted in multiple oblique planes to provide a complete assessment of the branching patterns and the tracheal and esophageal compression, if any at the same time.
Material and methodology:
A total of 834 cases that were done between January 2018 and June 2019, which had angiography of the arch of aorta and its branching pattern were included in the study. This retrospective study was done by evaluation of images available in the PACS at out department. The branching pattern was divided into conventional and unconventional patterns; and the abnormal branching pattern further divided according to the pattern recognized.
Results:
Out of the 834 cases we examined, 673 cases had a normal branching pattern which corresponds to 80.5% of the total. Rest of the other entire branching patterns (19.5%) that we examined for were found to have an abnormal branching pattern with Bovine arch pattern being the most common abnormality with 75 cases, corresponding to 9%. Thyroidea ima artery was seen in 42 cases which is 5% and variant origin of vertebral artery was seen in 33 cases which is 4% of the total cases. 8 cases showed aberrant right subclavian artery and 4 cases were aberrant left subclavian artery corresponding to 1% and 0.5% respectively
Conclusion*:.*
As radiologists it is important that the branching pattern of the aorta is included in the routine checklist of things assessed in images including the same and abnormal patterns mentioned in the report. Every radiologist must be therefore be well versed with the conventional branching pattern and the common anomalies in the branching pattern of the arch of the aorta.
Keywords: *Arch of aorta, bovine arch, Thyroidea ima artery, aberrant right subclavian artery, aortic arch anomalies and CT angiography of aorta.*

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I. Introduction:

Congenital aortic arch malformations present a large spectrum of variations and anomalies that emanate from disordered embryogenesis of branchial arches. These aberrations are the result of either abnormal persistence or involution of embryonic vascular segments. Clinically, these malformations can be asymptomatic in terms of their detection especially when imaging is being performed for some other reasons. However, these can be symptomatic in the form of difficulty in breathing or swallowing. These malformations can be isolated or they may be associated with other intra cardiac and/or chromosomal defects. Imaging plays a great role in the detection of these anomalies and thus helps much in accurate preoperative surgical decisions. The primary role of imaging is to detect these abnormalities and, importantly, to look for imaging features which indicate high risk of compression of the trachea and esophagus.

CT provides high spatial resolution evaluation of vascular anomalies and can be reformatted in multiple oblique planes to provide a complete assessment of the tracheal and esophageal compression simultaneously. CT is usually performed without use of gating which further reduces the exposure. High pitch spiral mode can be used without gating to drastically reduce cardiac pulsation artifacts (1). This may favor its increasing use, especially in pediatric patients, as CT may be performed without use of anesthesia or breath-holding (2).

Different aortic arch variations are described in the literature based on its embryology and the branching pattern. Some variations which are clinically more important are the following (3-8):

- Bovine arch
- Thyroidea ima artery
- Variant origin of vertebral artery
- Aberrant right subclavian artery
- Aberrant left subclavian artery
- Variant aortic branch vessels
- Bronchial arteries

II. Materials And Methods:

Study Design: This is an observational retrospective study.
Study Location: The study will be conducted in the Department of Radio-diagnosis in Yenepoya Medical College Hospital, Mangalore, Karnataka, India.
Study Duration: The study period is for 3 months, from June 2019 to August 2019. Cases will the collected retrospectively from June 2019.
Sample size: The sample size for this study is 834 cases.

Sample size calculation: The following formula will be used to calculate the sample size

$$\mathbf{n = \frac{Z^2_{1-\alpha/2} * p\ q}{d^2}}$$

where p = estimated proportion =0.13 (At 13% from related article)
q = 1-p
d= estimation error (margin of error) for 3 % taken = 0.03
Z= 1.96 at 5% level of significance
α is the level of significance 1%
Total sample size **is 'n' = 834**
Z is the standard normal deviate, which is equal to 1.96 at 5% significance level.

Subjects & selection method: All cases that fulfill the inclusion and exclusion criteria, including adults and children of both sexes and of all ages.

Inclusion criteria: All patients who underwent CECT study of the thorax from January 2018 to June 2019 with available images.

Exclusion criteria: Patients with non-availability of CECT images from January 2018 to June 2019.
Procedure methodology:

All the cases that full fill the study criteria in the PACS at our institution were retrospectively analyzed for the aortic arch branching variations that is being assessed in this study. The variations will be assessed based on the consensus of minimum of two expert radiologists (with a minimum of 7 years experience in radiology post MD/DNB) and reported. The images are acquired in our institution using a standard protocol which is as follows:

Protocol for CECT:

Multidetector CT angiography examinations were performed with a 16-row MDCT (LightSpeed Ultra, GE Healthcare, Milwaukee, WI). Patients were examined while in the supine position and all images were acquired during a single breath hold, extending from the base of the neck to the diaphragm. In adult patients, automatic tube current dose modulation was used. Imaging parameters were as follows: tube voltage, 100-120 kV; tube current, 140-300 mA, collimation, 16 × 1.25 mm; slice thickness, 1.25 mm; increment 0.6 mm; table feed, 27.5 mm/sec; rotation time, 0.5 sec. Imaging data was acquired after an intravenous injection of 1.5-2 ml/kg iodinated contrast agent (Iodixanol, 320 mgI/ml Visipaque, GE Healthcare) at a rate of 3-4 ml/sec. The scanning delay was determined with the use of a bolus tracking technique. The examination was initiated 4 seconds after the attenuation of a region of interest positioned in the ascending aorta reached 150 Hounsfield

units (HU). For three-dimensional image reconstruction, the raw MDCT data was processed on a separate workstation (Advanced Workstation 4.2, GE Healthcare) with multiplanar reformatting (MPR), maximum intensity projection (MIP), minimum intensity projection (MinIP) and volume rendering (VR). MIP and VR techniques were used mainly for evaluation of cardiovascular structures, the MinIP technique was used to evaluate the tracheobronchial air column and the MPR technique was used to evaluate both cardiovascular structures and the status of tracheal or esophageal compression.

Statistical analysis:

The data will be entered in Microsoft excel sheet. Appropriate descriptive statistical tests will be used to describe the data. The data will be analyzed using SPSS 21 trial version. The data is then tabulated and charts and graphs are made to better visualize the results and make it into a presentable format.

III. Results:

Our study was a retrospective study where cases done between January 2018 and June 2019 were examined to assess the branching pattern of the aortic arch.

Out of the 834 number of total cases we examined, we found that 673 cases had a normal branching pattern which corresponds to 80.5% of the total.

Rest of the other entire branching patterns that we examined for were found to be below 10% each; with Bovine arch pattern being the second most common with 75 cases, corresponding to 9%.

Thyroidea ima artery was seen in 42 cases which is 5% and variant origin of vertebral artery was seen in 33 cases which is 4% of the total cases.

8 cases out of the 834 cases examined showed aberrant right subclavian artery and 4 cases were aberrant left subclavian artery corresponding to 1% and 0.5% respectively.

Variants	No: of Cases (n=834)	Percentage (%)
Normal	672	80.5%
Bovine arch	75	9%
Thyroidea ima artery	42	5%
Variant origin of vertebral artery	33	4%
Aberrant right subclavian artery	8	1%
Aberrant left subclavian artery	4	0.5%
Total	**834**	**100%**

Table 1: Variations of aortic arch branching in 834 patients included in our study.

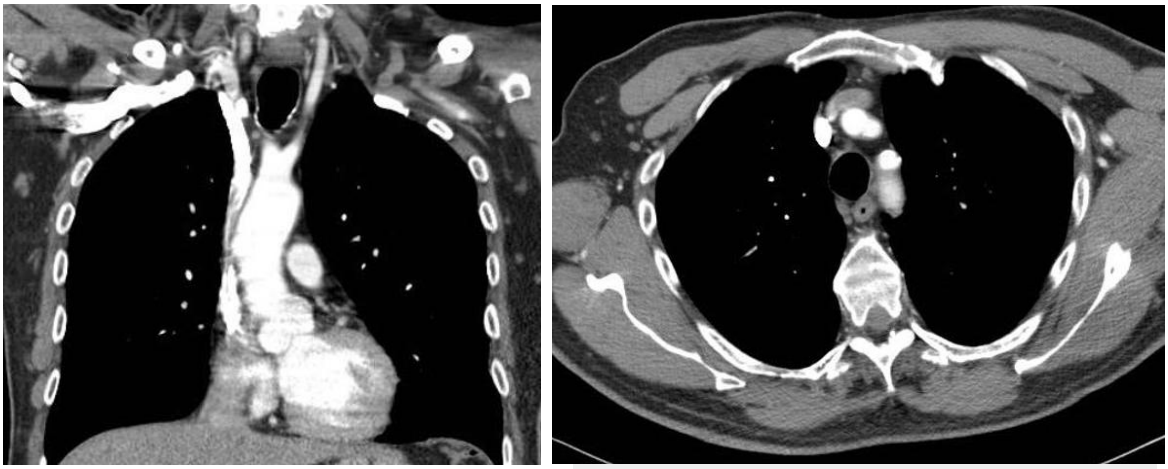

Image 1 and 2: Coronal and Axial images showing the left common carotid artery having a common origin with the brachiocephalic artery on the right- features are of a Bovine arch.

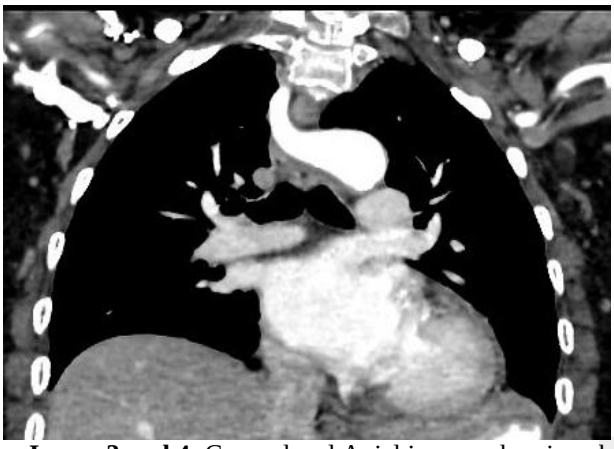
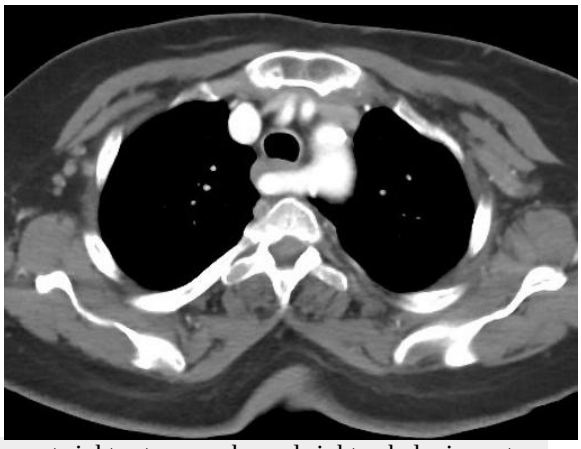

Image 3 and 4: Coronal and Axial images showing aberrant right retro-esophageal right subclavian artery

IV. Discussion:

The branching pattern of aorta is an important observation to be made while reporting contrast enhanced evaluation of the thorax. Even though normal branching pattern of the arch of aorta is seen commonly, the abnormal branching pattern of the aorta maybe the cause of the patients presenting complaints.

The presenting complaints of the patient may be due the effects of the abnormal branching pattern of the arch of aorta, as seen in the aberrant right subclavian artery which causes compression on the esophagus causing dysphagia; or it may me an incidental finding. In any case the identification of the branching pattern and reporting of any abnormality in the branching of the arch of aorta is of paramount importance.

In this study conducted in out institution, we analysed cases done over a period of 18 months and in the 834 cases that were retrospectively analysed we found 19.5% had an abnormal branching pattern of the arch of aorta, which corresponds to 162 cases and 80.5% which corresponds to 672 cases and the conventional configuration. This is almost similar to the study conducted by Jakanani GC et al[6], where 861 cases were analyzed and 26% had an abnormal branching pattern of the arch of aorta, while 74% of the cases corresponding to 643 cases.

In the same study[6] the most frequent anatomical variant was a common origin to the brachiocephalic and left common carotid artery (bovine arch), which occurred in 20% of the cases. Our study also finds that this anatomical variation is the most common, with 75 cases out of the 162 abnormal branching patterns identified being bovine arch. This corresponds to 9% of the total cases analysed and 46% of the abnormal cases we identified.

Even though the thyroidea ima artery is an uncommon variant of the blood supply to the inferior aspect of the thyroid gland, it was found to be the next most common abnormal pattern identified in our study after bovine arch with 42 cases corresponding to 5% of the total. The thyroidea ima artery was first described by Neubauer in 1786 and was originally called the thyroid artery of Neubauer**.** It can arise from brachiocephalic trunk (most common), right common carotid artery, aortic arch, internal thoracic artery or the subclavian artery and is often associated with absent inferior thyroid arteries. It is important to identify this variation, especially in cases where surgeries of the thyroid or parathyroid glands are part of the patient care.

In the study by Ullah SN et al[10] where surgical examination and conformation of presence of this uncommon variant was done, the incidence of thyroidea ima artery was found to be 4% of the total number of cases operated upon. This closely resembles the number of cases we identified in our study. Variant origin of vertebral artery was another abnormal pattern recognized in our study with a frequency of 4% (n=33) of the total number of cases studied. The vertebral arteries which are normally a paired branch arising from the subclavian arteries may have an abnormal origin where is arises from the aortic arch in some instances.

Karacan A et al[7] and Vučurević G[8] in their studies, where they also studied the branching pattern of the aortic arch using CT angiography of the aorta, found that the frequency of variant origin of vertebral artery as the abnormal pattern was 4.1% and 3.87% respectively. The number of cases examined in these studies was slightly higher than our study with 1000 cases in the study by Karacan A et al[7] and 1266 cases in the study by Vučurević G[8]. However, the percentage of variant origin of vertebral artery was almost similar to our study.

Aberrant origin of the right and left subclavian arteries was another unconventional pattern that was recognized in our study, but to a lesser extent. We had encountered 8 cases of aberrant right subclavian artery and 4 cases of aberrant left subclavian artery out of the 834 cases we examined.

Patients with aberrant right subclavian arteries are often asymptomatic. They may cause symptoms in patients depending on their relation to the trachea and esophagus and the degree of compression on these structures by the aberrant artery. In most cases the artery courses posterior to the esophagus, but may also be

seen traversing in between the trachea and esophagus or even seen anterior to the esophagus. Symptomatic patients represent with dysphagia termed as dysphagia lusoria if the compression is on the esophagus and they may present with stridor if the compression is on the trachea.

Aberrant left subclavian artery is generally seen with the right sided aortic arch. It is in most of the patients an incidental finding and does not cause any symptoms as such. It may however cause symptoms of compression on adjacent structures like those produced by the aberrant right subclavian artery and it may be associated with other cardiac anomalies.

Our findings of prevalence (1%, n=8) of the aberrant right subclavian artery are higher than the prevalence recorded in the study done by Karacan A et al[7] which showed 0.6% and that of aberrant left subclavian artery is similar with 0.5% in our study and 0.6% in the study done by Karacan A et al[7].

V. Conclusion:

Contrast enhanced CT evaluation of the thorax or the neck including the arch of aorta is a common study done in the department of radio-diagnosis at our hospital and in hospitals around the world. The branching pattern of the arch aorta is important to the clinicians as an unconventional branching pattern of the arch or aorta may be the cause of the symptoms that brought the patient to the hospital; or it may be crucial to the clinician in making the plan of care for the patient. As radiologists it is important that the branching pattern of the aorta is included in the routine checklist of things assessed in images including the same and abnormal patterns mentioned in the report.

Every radiologist must be therefore be well versed with the conventional branching pattern and the common anomalies in the branching pattern of the arch of the aorta.

References:

[1]. Lim HK, Ha HI, Hwang HJ, et al. Feasibility of high-pitch dual-source low-dose chest CT: Reduction of radiation and cardiac artifacts. Diagn Interv Imaging 2016; 97:443-9. 10.1016/j.diii.2016.01.007

[2]. McLaren CA, Elliott MJ, Roebuck DJ. Vascular compression of the airway in children. Paediatr Respir Rev 2008; 9:85-94. 10.1016/j.prrv.2007.12.008

[3]. Kau T, Sinzig M, Gasser J et-al. Aortic development and anomalies. Semin Intervent Radiol. 2007; 24 (2): 141-52.

[4]. Dasari TW, Paliotta M. Images in clinical medicine. Cervical aortic arch. N. Engl. J. Med. 2014; 371 (26): e38.

[5]. Bader V, Walayat M, Smith B et-al. Circumflex retroesophageal aorta mimicking aortic interruption: a rare cause of aortic obstruction in a neonate. World J Pediatr Congenit Heart Surg. 2014; 5 (4): 599-602.

[6]. Jakanani GC, Adair W. Frequency of variations in aortic arch anatomy depicted on multidetector CT. Clin Radiol. 2010; 65 (6): 481-7.

[7]. Karacan A, Türkvatan A, Karacan K. Anatomical variations of aortic arch branching: evaluation with computed tomographic angiography. Cardiol Young. 2014; 24 (03): 485-93.

[8]. Vučurević G, Marinković S, Puškaš L et-al. Anatomy and radiology of the variations of aortic arch branches in 1,266 patients. Folia Morphol. (Warsz). 2013; 72 (2): 113-22.

[9]. Cardiol Young. 2014 Jun; 24(3):485-93.

[10]. Ullah SN, Nizami SM, Anjum, I. Incidence of Thyroid Ima Artery. Medical Forum Monthly. 2013; 24(1):17-20.

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