Original Article

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Multidetector Computed Tomography Evaluation of Anomalies of Aortic Arch Branching

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Abstract

Background: Anatomic variations in the branching pattern of the aortic arch is known for a long time. Advances in modern medicine have led to an increasing number of endovascular and vascular reconstructive procedures where the pre-procedural information about these variations is extremely important. Besides, these variations may serve as a marker of thoracic aortic disease. Hence, we tried to evaluate the incidence of these anatomic variations in the branching of the aortic arch utilizing routine contrast-enhanced computed tomography of the thorax (CECT-Th) rather than aortograms. The aims and objectives is to the main aim of the study was to evaluate the role of multidetector routine CECT-Th in the detection of anomalies of branching of the aortic arch along with an estimation of their incidences. **Subjects & Methods:** Three-hundred and fifty CECT-Th examinations were included in our study over some time with the exclusion of 27 examinations. The type of aortic arch branching pattern was noted, and their incidence was calculated. **Results:** Majority of the patients in our study were in 41-60yrs age group with male predominance. Majority of the patients had three branches arising from the arch of aorta. The commonest variant was bovine type (14.2%) where the left common carotid arises from the right brachiocephalic artery followed by the isolated vertebral artery and aberrant right subclavian artery in the decreasing order of frequency. **Conclusion:** Anomalies of branching of aortic arch can be optimally detected on routine CECT-Th examinations performed on a multidetector CT scanner. Anomalies are seen in nearly one-fifth to one-quarter of subjects with the bovine type being the commonest and aberrant right subclavian artery being the rarest.

Keywords: Multidetector Computed Tomography, Anomalies, Aortic Arch.

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Introduction

The arch of the aorta (AA) which is a continuation of the ascending aorta forms an integral part of the superior mediastinum. It begins at the level of the manubriosternal joint on the right side of the midline to continue posterosuperiorly forming a dome to continue posteroinferiorly, ending into descending thoracic aorta at the level of the lower border of D4 or superior border of D5.[1] Various anatomical variations are known in the branching pattern of AA. These variations have significant implications in planning interventional vascular radiology & surgical procedures in the head & neck region as well as the upper limbs.[2,3] Also, in the era of modern medicine, there is a significant increase in the number of thoracic aortic stenting as well as hybrid aortic reconstructive procedures for a variety of pathologies involving AA. Hence, recognition of anatomic variations has assumed greater importance to ensure safer and more accurate endovascular as well as surgical procedures. In addition, literature also exists stating that the presence of variations in aortic arch branching is an independent potential marker for thoracic aortic disease.[4]

With the advent of multidetector computed tomography (MDCT) especially with 64-slice & 128-slice scanners, it is now possible to acquire high-resolution data at a very high-speed. Aortic angiogram performed on such scanners provide exquisite anatomical details of AA as well as its branching pattern. However, due to the isotropic resolution of MDCT, it is now also possible to incidentally recognize the majority of such anomalies with relative ease during routine contrast-enhanced computed tomography of the thorax (CECT-Th).[5] Hence, we planned a study to compare the incidence of these anomalies on CECT-Th with those existing in the literature.

Aims and Objectives

- To evaluate the role of MDCT in determining anomalies of branching of the aortic arch during routine CECT-Th examinations done for indications other than vascular causes.
- To determine the incidence of anomalies of branching of the aortic arch in our region.

Subjects and Methods

This observational, hospital-based, retrospective study was done including the CT examinations performed over a period of one year in the Department of Radiodiagnosis, Teerthanker Mahaveer Medical College & Research Center from December 2015 to November 2016.

Inclusion criteria

All routine CECT-Th examinations irrespective of age and sex were included in the study irrespective of the number of phases.

Exclusion criteria

• Studies with suboptimal quality due to motion (including respiratory) or any other artifacts interfering with optimal image assessment.

• Studies with pathological findings related to AA & its branches it may interfere with the final interpretation of images.

All CECT-Th examinations were performed on a 128-slice Philips Ingenuity CT scanner and the examined area extended from the C6-C7 vertebral level to the upper pole of kidneys. The slice thickness of examination was 0.67 mm with a pitch of 1.3 and an average gantry rotation time of 0.4 sec. Vascular access was obtained with an 18G or a 20G intravenous cannula inserted into the cubital vein. The volume of the non-ionic iodinated contrast agent used was as per the patient's body weight. The average rate of contrast agent administration with pressure injector was 3.0-4.5ml/sec. The contrast bolus was immediately followed by the saline chase.

The image data obtained were analysed using multiplanar, maximum intensity projections (MIP) and 3D-volume-rendered (VR) images. Branching patterns of the aortic arch were recorded as per the following patterns:[4]

1. Normal or Classic – one brachiocephalic artery [right common carotid (RCCA) & right subclavian branch (RSCA))], one left common carotid (LCCA) and one left subclavian artery (LSCA) in the order from right to left.
2. Bovine – one brachiocephalic artery (RCCA, RSCA & LCCA branch) and one LSCA in the order from right to left.
3. Isolated Vertebral – one brachiocephalic artery (RCCA & RSCA), one LCCA, one left vertebral (LVA) and one LSCA in the order from right to left.
4. Aberrant right Subclavian – one RCCA, one LCCA, one LSCA and & one RSCA in the order from right to left.

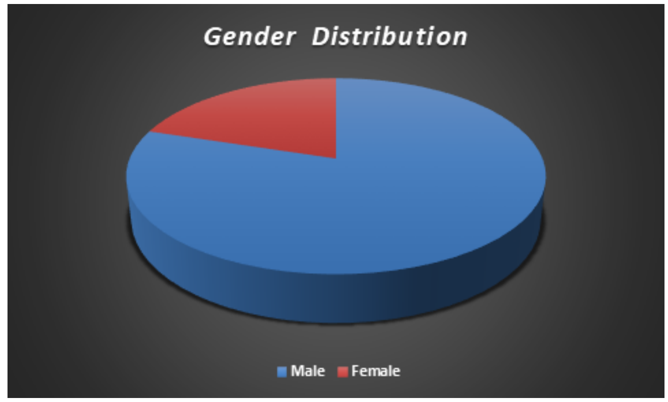

Figure 1: Pie diagram showing gender distribution in our study

The recorded data of anatomical variations in the branching pattern of AA was then used to calculate the incidence of individual anomalies.

Results

Three hundred and fifty routine CECT-Th examinations performed on a 128-slice CT scanner were included in our study. Out of these 27 examinations were excluded due to suboptimal quality or disease involving the aortic arch and/or its branches. Hence, finally 323 CECT-Th examinations were used to calculate the incidence.

In our study, males outnumbered females with 257 males and the rest females. The high number of males in our study may be because in developing countries males being the main earning member of the family seek medical attention earlier than the non-earning female member of the family who is often not offered medical examination due to financial constraints. [Figure 1] shows the gender distribution in our study.

Our study included patients from 01-20 to 61-80years age-group. However, maximum examinations were in the 41-60year age group as this is the most common age for thoracic evaluation due to the occurrence of a variety of pathologies in

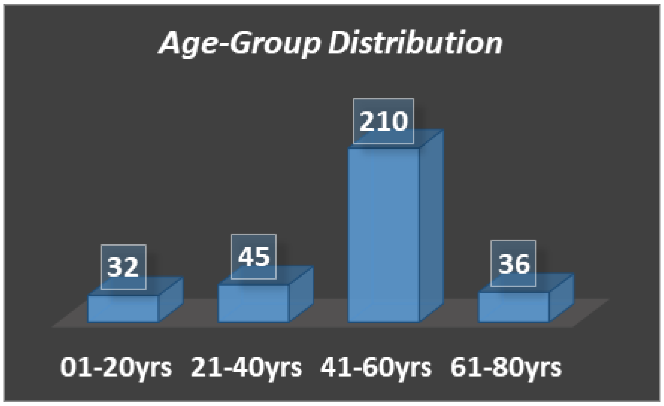

Figure 2: Bar-Chart shows Age-Group Distribution in our Study

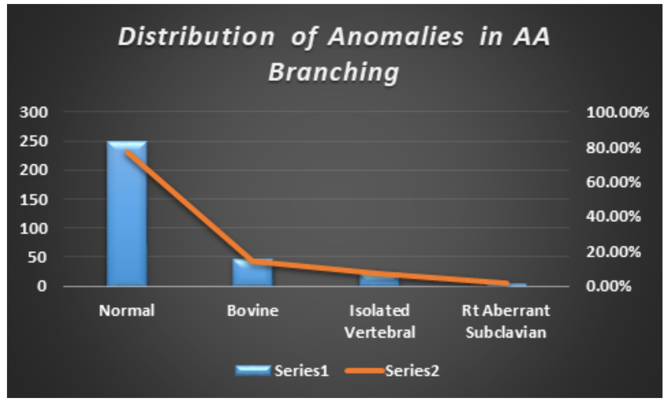

Figure 3: Shows the distribution of Anomalies ofBranching of AA in our Study

Table 1: shows the distribution of AA Branch Anomalies in our Study.

Variation in AA branching	Number of patients	Percentage
Normal	249	77.1
Bovine	46	14.2
Isolated vertebral	23	7.1
Aberrant right subclavian	5	1.6
TOTAL	**323**	**100%**

this age-group. [Figure 2] shows the age-group distribution in our study.

The commonest branching pattern of AA seen in our study was normal type followed by the bovine [Figure 4], isolated vertebral [Figure 5] & aberrant right subclavian [Figure 6] patterns in the decreasing order of frequency. [Table 1 & Figure 3] shows the distribution of various patterns of branching of AA in our study.

Figure 4: 3D-VR CT image showing Bovine type of AA - Left Common Carotid arising from Brachiocephalic artery

Discussion

Anatomically, the aortic arch (AA) gives rise to arterial branches that supply the head & neck region as well as the upper limbs. There are three main branches of the AA as it continues from its proximal anterior to distal posterior part viz. brachiocephalic artery (BCA), left common carotid artery (LCCA) and left subclavian artery (LSCA). BCA

Figure 5: 3D-VR CT image shows Left Vertebral type of AA – LVA arises directly from AA in between Left CCA & LSCA.

Figure 6: 3D-VR CT image shows Aberrant Right Subclavian type of AA – RSCA arises from Posterior part of AA after the origin of LSCA

further divides into right common carotid (RCCA) and right subclavian arteries (RSCA). This pattern is often referred to as the normal or classic pattern seen in the majority of the population. However, anatomic variations that have been described in the medical literature are as follows [Figure 7]:[4]

- Bovine type – In this type, the LCCA arises from the BCA. The only other direct branch is LSCA. Thus, there are only two direct branches of AA.
- Isolated vertebral type - In this type, in addition to three main branches of AA i.e. BCA, LCCA & LSCA, the left vertebral artery arises as a fourth branch. LVA originate in between the origins of LCCA and LSCA.
- Aberrant right subclavian type – In this type, the fourth branch of AA in addition to BCA, LCCA & LSCA is the RSCA originating posterior to LSCA and crossing the midline behind the esophagus to supply the right upper limb.

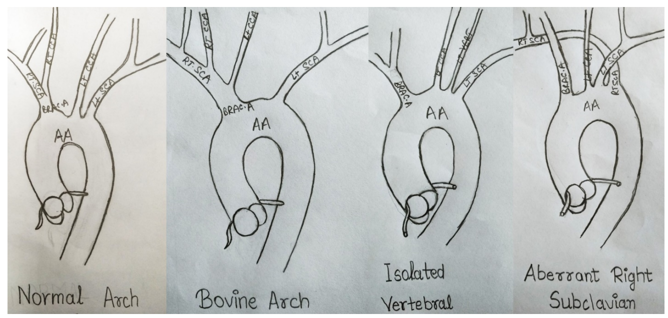

Figure 7: Schematic diagram shows the normal and variant patterns of AA Branches

The knowledge of these anatomic variations has assumed great significance due to the increasing number of endovascular and reconstructive procedures related to these arteries. Also, few recent studies have revealed that the presence of the above-described variations may be independent markers of thoracic aortic disease.[4] Patients with variations in the branching of AA usually suffer from thoracic aortic disease early in life.[4]

Studies like ours have been done in the past but are subjected to geographical, racial and CT scanner variations. In our study, the normal pattern was noted in approximately 77% which is very similar to that reported in the literature by Natsis et al and Popieluszko P.[3,6]

Incidence of bovine type of aortic arch was 31.1% in a study performed by Moorehead et al which is significantly higher than our study (14.2%) representing the racial differences as higher incidence is reported from the US and African countries.[7] Another study by Clerici et al however reported the incidence of a bovine type of AA to be 7.2-21.1%.[8] In one study, bovine type of AA was found to be a commoner anatomical variation in patients with embolic strokes.[9]

In our study, the isolated left vertebral artery was present in approximately 7% similar to that reported in medical literature as by 6% by Jakanani et al and 5% by Haifa et al.[5,10] However, the incidence of this anomaly has been reported to be as high as 14% in postmortem studies.[11] Though this anomaly is unlikely to have any significant hemodynamic consequence yet its pre-procedural information may obviate the cerebral flow compromise during aortic arch procedures.[11] However, authors have reported this anomaly to be an independent risk factor for developing dissection due to shearing forces secondary to the long extracranial course.[12]

The prevalence of aberrant right subclavian artery has been reported in various studies from 0.19-2.5% in various studies which is similar to our study (1.6%).[13] One study proposed a left transradial or transfemoral approach for aortogram or cerebral angiographic procedures instead of the right transradial approach in patients with aberrant right subclavian artery due to risk of puncture leading to potentially fatal complication.[14,15] This anatomical variation is also associated with a high risk of the right aberrant subclavian artery – esophageal fistula with long-term nasogastric intubation.[14]

Limitations

- Our study sample volume is not a true representation of the population as it is a hospital-based study.
- We have excluded cases with vascular pathologies where the anomalies may be commoner.

Conclusion

Multidetector CECT-Th is a highly versatile imaging technique that facilitates fast and comprehensive evaluation of the thoracic vasculature including the arch of the aorta and its branches even during routine examinations thus obviating the need for dedicated aortograms. The knowledge of various anatomic patterns in the branching of the aortic arch is not only needed prior to any endovascular or vascular reconstructive procedures but also serves as an independent marker of thoracic aortic disease. In our region, the incidence of anomalies of branching of AA is approximately 23% with the bovine type being the commonest and aberrant right subclavian artery being the rarest.

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