Great Blood Vessels Anomalies at Thoracic Inlet with CT Scan

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ABSTRACT: Over the past decade, faster computed tomography (CT) scan, thinner collimation, and the development of multi detector computed tomography (MDCT), coupled with the increasing capability of computers to process large amounts of data in short periods of time, have lead to an expansion in the ability to create diagnostically useful two-dimensional (2D) and three-dimensional (3D) images within the thoracic inlet. The objectives of the present study were to identify the CT angiographic appearances of vascular system and study the variable appearance of arterial and venous anatomy in thoracic inlet on contrast-enhanced, upper chest CT. In four hundred thirty-five patients who underwent spiral CT scan for either neck or thorax. The patients had different clinical symptoms. The cases included patients examined both with dual detectors row helical CT scanner and scanners that have a 16 detectors row configuration. Interpretation of axial and reformatted coronal and sagittal images were done by experts.

The results revealed that normal pattern of the great blood vessels were observed in 85.1% of study group and right internal thoracic vein draining into SVC were observed in 3.4% of study group. Bovine aortic arch was observed in 8.5 %, while in 0.9 % the left vertebral artery originated directly from the arch of the aorta. Aberrant right subclavian and thyroidea were observed in 0.3 % for each.

Conclusion: CT imaging appeared helpful in demonstrating the great vessels anomalies.

KEYWORDS; Great blood vessel, Anomalies, Computed tomography, Spiral CT.

INTRODUCTION: The vascular anomaly is insufficiently demonstrated by conventional radiographic techniques, unless the vascular anomaly is interfered with low attenuation lung field, like aberrant right subclavian artery which can be seen on chest x-rays (CXR) as an edge along its interface with the lung. It will be seen running from the left side immediately above the aortic knob, across the midline to the right superior mediastinum. On lateral views, there may be obscuration of the posterior aspect of the aortic arch by the aberrant vessel (1,2). CT is used because it clearly demonstrates this area free from superimposition, accurately depicts the size, shape and abnormalities of the thoracic inlet structures (2,3).

Vascular structures are usually readily identified on (CT) scans of the chest with intravenously administered contrast medium. From a single helical scan, vascular structures can be reformatted in any plane or rendered in three dimensions (3D), providing a simplified display of even most complex vascular anatomy (3,4,5). Helical images of thorax obtained with 60 ml of 60 % iodinated contrast material were judged to have superior vascular contrast enhancement to that of conventional CT images obtained with 120 ml of 60% contrast material (6, 7, and 8).

Objectives To identify the CT angiographic appearances of vascular system in thoracic inlet and to study the variable appearances of arterial and venous anatomy and thoracic inlet structures on contrast-enhanced, upper chest CT.

MATERIALS and METHODS The study group consisted of 435 patients who underwent spiral CT scan for either neck or thorax, they had different clinical symptoms. The cases included patients
examined both with dual detectors row helical CT scanner and scanners that have a 16 detectors row configuration. All patients were studied for clinical purposes rather than research interest. One hundred and seven patients were excluded from the study due to marked deformities in their thoracic inlet noted in the axial CT images. Written consents were taken from all patients included in this study.

CT Protocol

All scans were acquired after the initiation of an antecubital intravenous catheter. If possible, the intravenous catheter should be in place before the patient arrives in the CT site. This reduces patient agitation that otherwise would be associated with a venipuncture injection of iodinated contrast medium; (70-100 ml, approximately 300 mg iodine concentration) of non-ionic contrast. The contrast was injected with 25-35 sec delay time. This dose will establish a bolus duration that is equivalent to the scanning duration. The contrast material was injected automatically at a rate of 2-2.5 ml/second. Scan delay time for chest is 35 sec and for the neck 25 sec. For some patients, the contrast maximum enhancement was determined by smart preparation technique in which contrast enhancement of thoracic inlet and neck structures is measured with circular regions of interest during initial fast scan, followed by the proper scan when the contrast maximum enhancement was reached in the region of interest. The caudocranial helical acquisition was planned on the basis of a lateral digital scout view of the neck or frontal view of the chest, which starts at the top of the aortic arch and ends at the base of the skull in case of neck and starts at upper abdomen to the root of the neck in case of thorax.

Image Interpretation

For evaluation of images and to measure the size, and relate the anatomic structures in thorax inlet using the CT images the following window setting was made, soft tissue window for lymph nodes, blood vessels and muscles, lungs window to view lung parenchyma in apex area and bone window to view ribs, clavicles scapula and vertebrae. Each of the anatomic structures in the thoracic inlet was identified; this was confirmed by comparing these images with photographs of cryosections and drawings of the thoracic inlet region from an atlas. For accuracy, the identification was carried out initially by using a set of axial source images followed by images viewing in the additional planes.

RESULTS

Normal pattern of the great blood vessels were observed in 85.1% of the study group. One hundred fifty one (87.4%) of the 174 male patients had normal vascular pattern. One hundred twenty seven (82.5%) of 154 of the female patients had normal vascular pattern. Right internal thoracic vein draining into SVC were observed in four (2.3%) of the 174 male patients in study group. Seven (4.5%) of the 154 female patients. Thirteen (7.5 %) of the 174 male cases and fifteen (9.7%) of the 154 female cases had bovine aortic arch. In three (1.7%) of the 174 male cases, the left vertebral artery originated directly from the arch of the aorta, and not observed at all in female group. Aberrant right subclavian and thyroidaeama were observed in one (0.6 %) for each in male. Four (2.6%) from female group has aberrant right subclavian artery and none of them had thyroidaeama. Two brachiocephalic arteries were found in one (0.6%) of the 154 female groups (Table 2). These results are shown in Tables 1, 2 and Figures 1-8.

Table 1 : Study group gender and age frequencies (years)
**Table 2. Anatomical variations of blood vessels in study group.**

<table>
<thead>
<tr>
<th>Anatomical variant</th>
<th>Male No.</th>
<th>Male %</th>
<th>Female No.</th>
<th>Female %</th>
<th>Total No.</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>152</td>
<td>87.4</td>
<td>27</td>
<td>82.5</td>
<td>9</td>
<td>85.1</td>
</tr>
<tr>
<td>Right internal thoracic vein draining into SVC</td>
<td>4</td>
<td>2.3</td>
<td>7</td>
<td>4.5</td>
<td>1</td>
<td>3.4</td>
</tr>
<tr>
<td>Bovine aortic arch</td>
<td>13</td>
<td>7.5</td>
<td>15</td>
<td>9.7</td>
<td>18</td>
<td>8.5</td>
</tr>
<tr>
<td>L.V.A.O Aortic arch*</td>
<td>3</td>
<td>1.7</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>0.9</td>
</tr>
<tr>
<td>Aberrant Rt. subclavian</td>
<td>1</td>
<td>0.6</td>
<td>4</td>
<td>2.6</td>
<td>5</td>
<td>1.5</td>
</tr>
<tr>
<td>Thyroideama</td>
<td>1</td>
<td>0.6</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>0.3</td>
</tr>
<tr>
<td>Two bachiocephalic arteries</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>0.6</td>
<td>1</td>
<td>0.3</td>
</tr>
<tr>
<td>Total</td>
<td>174</td>
<td>0</td>
<td>54</td>
<td>100</td>
<td>28</td>
<td>100</td>
</tr>
</tbody>
</table>

*Left vertebral artery originated from aortic arch.

**Figure 1. Study gender group age frequencies (years)**

**Figure 2. Anatomical variations of blood vessels in study group.**
Figure 3. Internal thoracic vein. Axial contrast-enhanced CT scan shows internal thoracic vein (arrow) draining into SVC, in a 79 years woman.

Figure 4. Bovine aortic arch. Coronal reformatted contrast-enhanced CT scan shows bovine aortic arch arrow (common origin of barchiocephalic artery and left common carotid artery), in a 58 years woman with left lobe of thyroid mass.

Figure 5. Bovine aortic arch. Axial contrast-enhanced CT scan of bovine aortic arch (arrow), in a 33 years old man.
DISCUSSION
An anomalous of blood vessel is rare. With the widespread application of noninvasive imaging techniques such as sonography, CT, and MRI, however, it is increasingly being recognized. The most likely interpretation is that the frequencies of the standard aortic arch, (where there are three great vessels that originate from the arch; the brachiocephalic trunk subsequently branches into right common carotid artery and right subclavian artery) was found to be the most common anatomical appearance in the study. The incidence of this pattern is found to be 85.1% in the study group, with higher percentage in men (87.1%) than women (82.5%) (Table 2). A study by Troyer (9) showed a percentage less than the above (70%), and this may be
explained on ethnic group variations and the technique used for the study. Three types of anatomical variations of aortic arch pattern were noted in this study they include; common origin of brachiocephalic artery and left common carotid artery (bovine arch), in which there were only 2 great vessels originating from the arch, with an average of 8.5% in the study group with 7.5% among men group and 9.7% among women (Table 2). This correlates with the findings of Layton (10) in his study which revealed an average of 8%.

Variations in the origin of the vertebra arteries usually occur on the left (11) and anomalous origin of left vertebral artery may be present in about 5% of individuals. The artery may arise from the aorta, or common carotid artery (12). In this study variation of origin of left vertebral artery was noted only in 0.9% of study population and all were men. Left vertebral artery originating from common carotid artery was not seen at all. The difference seen in the result may be due to difficulty of demonstrating the exact origin of the artery when its origin is from the common carotid artery in thick slices of axial CT images.

The right subclavian artery usually arises as a branch of the brachiocephalic trunk. Aberrant right subclavian artery is a congenital anomaly of the aortic arch. The artery runs to the right posterior to esophagus. This anomaly is present in about 0.5% to 1% of population (13,14) (Table 2). The affected people are typically asymptomatic, but the condition may cause dysphagia (dysphagia lusoria). In this study, this anomaly was found in 1.5% of the study population, (men 0.6%, and women 2.6%) (Table 2). All the affected people were asymptomatic, and result conform to the findings of other authors (11,12)

Thyroidea ima is a small branch, occasionally arises from the right brachiocephalic, the aorta, the common carotid, the right subclavian or the internal thoracic artery. The thyroidea ima ascends in front of the trachea to the lower part of thyroid gland, which it supplies (13). In this study thyroidea ima variation occurred in about 0.6% of cases. In other studies variation were seen in 4 to 10% (16,17). The frequency is variable and it can be as low as 0.4% (18) or as high as 10% (16,17).

The brachiocephalic artery is an artery of the mediastinum that supplies blood to the right arm, neck and head. It is the first branch of the aortic arch. Soon after it emerges, the brachiocephalic artery divides into the right common carotid artery and right subclavian artery. There is no brachiocephalic artery for the left side of the body, the left common carotid, and the subclavian artery, come directly from the aortic arch, however there are two brachiocephalic veins (13). In this study two brachiocephalic arteries were found in about 0.6% of cases. Such a variation was not reported by CT images in other studies, but absence of the brachiocephalic trunk was noted in 0.44% by Bergman et al (11).

Knowledge of the internal thoracic vessel anatomy is important to avoid hemorrhagic complications when an anterior parasternal approach is used for percutaneous transthoracic procedures, such as CT guided biopsy and empyema drainage, because their appearance can mimic pathology when there is anomalies in their pattern. These vessels have received increased attention in recent clinical literature, largely from the discovery of their involvement in breast reconstruction, reconstruction of complex thoracic wall defect, their frequent use in cardiac surgery and are generally accepted as coronary artery bypass (19).

The most common venous variations noted in this study was a right internal thoracic vein (RITV), which drain drained into the superior vena (SVC). This was in about 3.8%, of the study population, (2.3 % of men and 4.5 % of women). However, on the left side, the internal thoracic vein termination was normal. Standard
anatomy textbooks show that the internal thoracic veins (ITVs) are connected at the point of manubriosternal joint. The RITV and LITV receive the posterior intercostal veins to form common trunks that ascend and drain into the right and left brachiocephalic veins respectively \(^{(20)}\). Vollala et al \(^{(18)}\) observed a rare variation of right internal thoracic vein draining into the extra-pericardial part of the superior vena cava about 1.5 cm distal to the junction of the right and left brachiocephalic veins. Such a variation was not observed in this study.

Superior vena cava anomalies are of rare occurrence caused by variations in the development of the embryonic venous system. Persistent left superior vena cavae are the most common congenital aberrations in the thoracic venous system, with an incidence of 0.3-0.5\%. \(^{(21)}\) In this study no anomalies concerning SVC were noted. The clinical significance of anatomical variants of thoracic inlet vasculature is given less attention by radiologists. Most of studies \(^{(22, 23)}\) of this topic have been made in normal individual or patients suspected of having unrelated pathology. One study found that most of patients had dysphagia in case of aberrant subclivian artery \(^{(23)}\).

**CONCLUSIONS**

CT is superior to radiology for identification of normal anatomy, anatomic variants and early abnormalities or pathological processes. CT angiography is promising method for both detection and therapy planning of great vessels anomalies. MDCT is a useful, less invasive technique for diagnosing most types of vascular variations. It provides useful information to differentiate lymph nodes and small soft tissue lesions in thoracic inlet from blood vessels. The combination of MDCT and volume rendering (VRT) provides higher quality data sets which previously required two radiological studies which may, in case of conventional angiography, be much more expensive than CT.

Two effects facilitate the viewing of thoracic inlet structures, the delineation of the thoracic inlet muscles from the lymph nodes, and the enhancement pattern of blood vessels by contrast media in MDCT compared to the appearance of these structures with non enhancement study. The contrast-enhanced CT imaging can assess both the normal anatomy and variations of thoracic inlet structures accurately. Reformatted sagittal and coronal CT sections may help to show the origin, pathways the size and shape of thoracic inlet structures. CT should be used as a procedure of choice for diagnosis of thoracic inlet blood vessel abnormalities, especially in patients suspected to have vascular obstruction.

Clinicians and technologist should be aware of the characteristic findings of non-contrast-enhanced as well as contrast-enhanced images.

The wide spectrum of variations in anatomical arrangements of aortic arch branches in this study population was similar to those of other studies. Although anomalous origins of the aortic arch are congenital, accurate knowledge of these variations are vital for vascular surgery in the thorax, and the neck region. The present study findings may be useful in the planning for thoracic inlet surgery and may induce a change of surgical strategy. It recommended that checking the vascular variants and position of great blood vessels and other structures should be done before surgery.

There is a potential hazard from I.V. administration of iodinated contrast material, in CT compared to other images modalities (MRI, US), in addition thoracic inlet zone is prone to CT beam hardening artifacts from the thickness of the shoulders, often resulting in poor quality images.

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REFERENCES