Original Research Article

Role of CT angiography in congenital and acquired aortic diseases

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Abstract

Background: Multidetector CT is an alternative tool helpful in establishing the primary diagnosis, defining anatomic landmarks and their relationships, and identifying associated cardiovascular anomalies in both congenital and acquired aortic diseases. **Aim:** To establish the role of CT angiography in congenital and acquired aortic diseases. **Material and Methods:** The study included 50 Patients presenting with sign and symptoms of aortic diseases or incidental detection of aortic diseases in asymptomatic patients. All patients were studied with 128 slice MDCT Aortic Angiography. **Results:** In the spectrum of aortic pathologies, 13 patients (26%) were of congenital category and 37 patients (74%) were from acquired category. Two (4%) patients had vascular ring. In both abnormal/aberrant vessel (right subclavian artery) was coursing posterior to oesophagus.In one (2%) patient some type of abnormal communication between aorta and adjacent vascular structure was found. This patient had patent ductus arteriosus of type C.Aortic dissection was seen in 13 patients. **Conclusion:** With its high spatial resolution, multidetector CT performed with or without an ECG-gated technique allows accurate and fast noninvasive characterization of aortic pathologic conditions
Key Word: Multidetector CT angiography, aortic diseases, congenital, acquired aortic diseases

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INTRODUCTION

The spectrum of aortic diseases is dominated in most cases by the common pathologic conditions, which include atherosclerosis-related aortic aneurysm, mural thrombus, dissection, etc. Radiologists should also be familiar with uncommon aortic diseases, some of them congenital in origin.[1] With the advent of new noninvasive imaging methodslike multidetector computed tomography (CT) technology with increased z-axis coverage, higher spatial resolution (smaller detectors), and higher temporal resolution (faster 360° rotation times), evaluation of the aorta and its branches is possible with faster imaging times, fewer motion artifacts, and also less contrast material volume. These methods have mostly replaced invasive angiography when aortic disease is suspected.[2] Multidetector CT is an alternative tool helpful in establishing the primary diagnosis, defining anatomic landmarks and their relationships, and identifying associated cardiovascular anomalies in both congenital and acquired aortic diseases.[3] Therefore, this study was planned to establish the role of CT angiography in congenital and acquired aortic diseases.

MATERIAL AND METHODS

This descriptive cross sectional study was carried out in Department of Radiodiagnosis, in collaboration with department of cardiology and CTVS of a tertiary care hospital. The study included 50 Patients presenting with sign and symptoms of aortic diseases or incidental detection of aortic diseases in asymptomatic patients. All patients were studied with 128 slice MDCT Aortic Angiography.

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Inclusion Criteria

1. All adult patients (more than 14 years of age) presenting with sign and symptoms suggestive of aortic disease.
2. Asymptomatic adult patients with incidental detection of aortic disease.
3. Patients referred for imaging follow up of treated aortic diseases.

Exclusion Criteria

1. Patients with history of allergy to iodinated contrast agent.
2. Patients with deranged renal functions.
3. Very sick patients who are unable to hold breath.

METHODOLOGY

CT angiography wasperformed with 128-slice Philips Ingenuity Core CT scanner. Images were processed using intellispace portal software.The complete CT angiographic study was explained to each subject with risk involved during and /or after intravenous contrast administration and radiation exposure during the CT study. Blood urea and serum creatinine levels were checked before intravenous contrast administration. MDCT was carried out after 6 hours of fasting. Scout was taken from the level of thoracic inlet to the level of aortic bifurcation (modification was done according to pathology suspected). Non contrast CT was performed first. After that contrast was injected and Angiographic study was performed. Venous phase and delayed phase were taken in selected patients. Image acquisition was carried out adhering to ALARA (as low as reasonably achievable) protocol. In most of the patients routine scanning was performed. In selected patients ECG gating was done.Contrast volume was adopted to scan protocol. The contrast used was low osmolar non-ionic water soluble contrast (ULTRAVIST).The goal of contrast administration was to achieve homogenous vascular enhancement synchronized with image acquisition. Great care was taken regarding the intravenous access, dose and density of contrast material and rate of injection. For all the CT angiography examinations, an automatic double head injector was used for contrast administration, using a biphasic injection at a flow rate of 4.5 to 5 ml/s. The volume (*V*) of non-ionic iodinated contrast was calculated using the equation: V= (scan delay + scan time) × flow rate, followed by 50ml of saline solution at the same rate. For timing purposes, a bolus test technique / automatic triggering (Care Bolus) technique was used with the region-of-interest (ROI) placed in the descending aorta at carinal level. The scanning was started when a threshold of 100 HU was attained. An additional delay of ten seconds was added after the desired HU value was attained at the ROI. Contrast at a dose of 1.5-2 ml/kg was injected at the rate of 2.5-4.5 ml/sec at a pressure of 150 to 175 psi followed by saline flush. Image processing and data analysis was performed on a separate workstation using Intellispace portal software. 2D reconstruction was performed by curved multiplanar reformations (MPR) and Maximum intensity projection (MIP).These allows curved and tortuous vessels and their branches to be visualized in a single tomography volume. Minimum intensity projections were used to evaluate the airway. For 3 dimensional reformatting of complex anatomy, the volume rendering technique was used

RESULTS

The age range of cases varied from 14 years to 83 years with maximum number of cases in 31-40 years age group. (20%). 70% patients (35 out of 50) included in study were male and 30% patients (15 out of 50) were females. Male female ratio was 2.33:1.Cases were divided into congenital and acquired types. In the spectrum of aortic pathologies, 13 patients (26%) were of congenital category and 37 patients (74%) were from acquired category.

Table 1: Congenital V/s acquired

Etiology	No. of patients	Percentage
Congenital	13	26%
Acquired	37	74%
Total	50	100%

All the 100% patients (50 out of 50) had normal origin of aorta from left ventricle. 90%patients (45 out of 50) had normal left sided aortic arch. 8% patients (4 out of 50) had abnormal branching pattern of aortic arch. 4% patients (2 out of 50) had aberrant right subclavian artery with formation of vascular ring. 4% Patients (2 out of 50) had Bovine arch configuration in the form of common origin of brachiocephalic artery and left common carotid artery. Two (4%) patients had vascular ring. Vascular rings are uncommon anomalies (<1% of all congenital cardiac defects) with a similar frequency in both sexes. In both abnormal/aberrant vessel (right subclavian artery) was coursing posterior to oesophagus.

In one (2%) patient some type of abnormal communication between aorta and adjacent vascular structure was found. This patient had patent ductus arteriosus of type C. Aortic co-arctation was found in 18% patients (9 out of 50). Out of these 9 patients, all the patients had pure aortic co-arctation.Nobody had co-arctation with tubular hypoplasia. Female to male ratio was 2:1. A total of 46 (92%) patients had tricuspid valve. 2 patients (8%) had cusp morphology of bicuspid type. 50% patient (1 out of 2) had associated coarctation. 50% patient (1 out of 2) had ascending aorta aneurysm. 2

patients out of 50 (4%) had prosthetic valves. No patient had unicuspid aortic valve. Out of 50 patients, 8% patients (4 out of 50) had diseased valve in form of leaflet thickening and valve stenosis. Out of these 4 patients, 75% patients (3 out of 4) had associated calcification of valve leaflets. Out of these 4 patients, two patients had ascending aortic aneurysm, one patient had infrarenal aortic aneurysm.25% patient (1 out of 4) had non calcified thickened valve, associated with takayasu arteritis.

Table 2: Spectrum of aortic diseases by 128-slice CT Angiography

	No. of patients	Percentage
No. of cusps		
Tricuspid	46	92
Bicuspid	2	4
Unicuspid	0	0
Others	2	4
Aortic valve stenosis (n=4)		
Thickened and calcified	3	75
Thickened and non-calcified	1	25
Direction of arch		
Left sided	50	100
Right sided	0	0
Double aortic arch	0	0
Left sided and circumflex	0	0
Communication pathology		
PDA	1	2
AP window	0	0
AV fistula	0	0
Normal	49	98
Branching Pattern of Arch		
ARSA	2	4
Bovine Arch	2	4
Normal	46	92
Vascular Ring		
Yes	2	4
No	48	96

Some form of aortic stenosis (including aortic valve to its bifurcation and aortic branches was found in 19 patients (38%). One patient (2%) had thrombosis and stenosis of aortic stent graft. Aortic stenosis increases with age, being present in 2% to 4% of adults over age 65 years. Aortic dissection was seen in 13 patients (26%). Out of these 13, 5 patients (38.4%) had Stanford type A dissection (involvement of ascending aorta) and 8 patients (68.5%) had Stanford Type B dissection. Out of 5 patients with Type A dissection, one patient also had undergone Bentall procedure for aortic root replacement and also had infrarenal aortic aneurysm. Two patients had traumatic Stanford type B dissection. Different signs were studied on CT angiography to differentiate true lumen from false lumen. 10 out of 13 patients (76.9%) had beak sign in false lumen. 4 out of 13 patients (30.7 %) 2 patients (15.3%) had intraluminal thrombus in false lumen. None of patient had outer wall calcification or eccentric flap calcification. Takayasu arteritis was found in 5 patients (10%). Out of these 5, all the patients (100 %) were females. 2 (40 %) patients were in 3rd decade of life and 2 (40 %) in 2nd decade of life.1 patient was in fourth decade of life. In our study 16 patients (32 %) had aortic aneurysms. 93.25 % patients had true aneurysm, while 6.75 % patients had pseudo or false aneurysm. 3 patients had saccular aneurysm, while 13 patients had fusiform aneurysms. 87.5 % patients (14 out of 16) had single aneurysm and 12.5 % patients (2 out of 16) had multiple aneurysms. Aortoiliac occlusion (Leriche syndrome) with collaterals was found in one patients. There was extensive collateralization from systemic and visceral vessels with reformation of lower limb arteries. The exact length of occlusion could be calculated by using CT Angiography. Detailed study of collateral circulation was possible with the help of CT Angiography.

DISCUSSION

Aortic disease is often associated with significant morbidity and mortality. Aortic pathology is often more challenging to understand and correctly diagnose with imaging than is initially appreciated. Multidetector CT has excellent isotropic spatial resolution that led to this technique becoming pre-eminent in the evaluation of the

acute aorta. In our study 4% patients had vascular ring.In these patients abnormal/aberrant vessel (right subclavian artery) was coursing posterior to oesophagus.A vascular ring is an aortic arch anomaly in which the trachea and esophagus are surrounded by vascular structures.[4]Vascular rings are uncommon anomalies accounting for less than 1% of all congenital cardiac defects with a similar frequency in both sexes. According to Turkvatan A *et al*, MDCT angiography enables one to display the detailed anatomy of vascular structures and the spatial relationships with adjacent organs.[5]According to Lowe GM *et al*, CT and MRI add valuable information about exact arch configuration, tracheobronchial compression, brachiocephalic vessel branching.[6] In one patient some type of abnormal communication between aorta and adjacent vascular structure was seen. This patient had had type C (tubular type without any constrictions). Accurate morphology of duct could be delineated using CT Angiography. According to Goitein O *et al*, small PDAs can be missed on routine echocardiography. MDCT angiography can show incidental PDAs. MDCT enables precise visualization of the location, size, presence and extent of calcification, and the relationship to adjacent anatomic structures.[7] Aortic coarctation was found in 18% patients. All the patients had pure aortic coarctation. Nobody had coarctation with tubular hypoplasia. Omnia AK *et al* and Turkvatan A *et al* found that the overall sensitivity of three-dimensional MDCT angiography for diagnosis of the coarctation of the aorta was 100%. They concluded that MDCT angiography with multiplanar and 3D techniques should be the method of choice for preoperative morphologic assessment of coarctation of the aorta in adult patients.[5,8] MDCT is the definite means of assessing aortic valvular calcification, acute aortic syndrome and for non-invasive assessment of the coronary arteries.In present study, 92% patients had tricuspid valve. 8% patients had cusp morphology of bicuspid type. 50% patient of these patients had associated coarctation.According to Sievers HH *et al* bicuspid aortic valve is the most common congenital cardiovascular anomaly, with a prevalence of 1–2% in the general population.[9]In addition, multiple congenital cardiovascular abnormalities are associated with a bicuspid aortic valve, notably, coarctation of the aorta.[10] 13 patients (26%) had aortic dissection. Out of these, 5 patients (38.4%) had Stanford type A dissection (involvement of ascending aorta) and 8 patients (68.5%) had Stanford Type B dissection. According to Karmy-Jones R *et al* Type A dissections account for 60-70% of cases. Stanford type B dissection accounts for 30-40% of cases.[11] Different signs were studied on CT angiography to differentiate true lumen from false lumen. 10 out of 13 patients (76.9%) had beak sign in false lumen. LePage MA *et al*did a study to determine which CT findings are reliable indicators of the true or false lumen in an aortic dissection. They concluded that the beak sign and a larger cross-sectional area were the most useful indicators of the false lumen for both acute and chronic dissections.[12] In our study, 16 patients (32%) had aortic aneurysms. Morphological features of all aneurysm and associated complications were very well detected on CT Angiography. 21 patients had atherosclerosis. Out of 21 patients with atherosclerosis, most common imaging finding was wall calcification. According to Deif R *et al* MDCT is more sensitive than TEE in detecting atherosclerotic aortic arch plaques and better characterization of these plaques.[13] According to Kronzon I *et al*unenhanced dual-helical CT with thin sections has been reported to be successful in detecting protruding aortic plaque, especially in areas not visualized by TEE.[14] CT provides complete imaging of the thoracic aorta, whereas TEE does not. New MDCT scanners allow synchronous imaging with the cardiac cycle, thereby reducing artefacts in the ascending aorta and the aortic root.

CONCLUSION

The spectrum of aortic disease is broad and varied. It includes common acquired potentially life-threatening disorders such as aneurysm and dissection secondary to atherosclerosis. It also includes uncommon congenital conditions such as hypoplasia of the aortic arch, vascular rings and large-vessel vasculitis. With its high spatial resolution, multidetector CT performed with or without an ECG-gated technique allows accurate and fast noninvasive characterization of aortic pathologic conditions.

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