Original Research Article

Spectrum of aortic diseases in adults using 128 slice CT angiography

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Abstract

Background: Aortic pathology is often more challenging to understand and correctly diagnose.128-slice CT angiography has good temporal resolution, high scanning speed as well as low radiation dose thus become a useful first-line imaging modality to accurately evaluate the entire spectrum of aortic diseases. **Aim:** To study the spectrum of aortic diseases in adults using 128-slice CT angiography. **Material and Methods:** CT angiography was performed in 50, aged more than 14 yrs, patients presenting with sign and symptoms of aortic diseases or incidental detection of aortic disease in asymptomatic patients.Image processing and data analysis was performed using Intellispace portal software. 2D reconstruction was performed by curved multiplanar reformations (MPR) and Maximum intensity projection (MIP).For 3 dimensional reformatting of complex anatomy, the volume rendering technique was used. **Results:** Out of 50 patients, 13 (26%) were of congenital category and 37 (74%) were from acquired category.13 patients (26%) had aortic dissection. Out of these, 5 patients (38.5%) had Stanford type A dissection (involvement of ascending aorta) and one patient (61.5%) had Stanford Type B dissection.16 patients (32%) had aortic aneurysms. 93.25% patients had true aneurysm, while 6.75% patients had false aneurysm. 87.5% patients (14 out of 16) had single aneurysm. **Conclusion:** CT angiography is one stop shop for both intra and extraluminal aortic pathologies. 128-slice CT scanner generates better quality images with minimum amount of radiation as compared to previous generation CT.

Key Words: Aortic diseases, 128-slice CT angiography, diagnosis, visualization.

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INTRODUCTION

Computed tomography (CT) plays a central role in the diagnosis, risk stratification, and management of aortic diseases. Its advantages over other imaging modalities include the short time required for image acquisition and processing, the ability to obtain a complete3D dataset of the entire aorta, and its widespread availability.[1,2] Aortic pathology is often more challenging to understand and correctly diagnose. Aortic disease is often associated with significant morbidity and mortality. The clinical presentation is frequently non-specific and the pathology can often be discovered incidentally on imaging. Multidetector CT angiography is often the modality of choice for the diagnosis of aortic diseases.[3] With the advancement in technology efforts have been made to increase the accuracy in diagnosing aortic diseases. Aortic imaging is the challenge of 21st century and it is being answered by 128 slice CT angiography as it has good temporal resolution, high scanning speed as well as low radiation dose. In present study an effort was made to study the spectrum of aortic diseases in adults using 128-slice CT angiography.

MATERIAL AND METHODS

This study was conducted in the department of Radiodiagnosis, Ruby Hall Clinic, Pune in collaboration with the Department of Cardiology and Cardiothoracic and vascular surgery. It was a descriptive cross sectional study of 50 patients presenting with sign and symptoms of aortic diseases or incidental detection of aortic disease

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in asymptomatic patients. All patients underwent CT Angiography for aortic evaluation. It was carried out after obtaining sanction from the Institute Research Committee and Ethical Committee and after obtaining an informed consent from each patient.

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 was performed 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 will be 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. Imaging findings from different imaging modalities were noted. CT angiographic evaluation of aorta was done under different headings like origin of aorta, direction of arch, segment involved, characteristics of aortic wall, presence of any thrombosis/stenosis/dissection/ aneurysm and any extraluminal findings. Follow up of patients was taken.

Statistical Method: Data was entered in excel and analysed using SPSS (Statistical Package for the Social Sciences. Quantitative variables were evaluated using t-test and qualitative variables were evaluated using Chi-square test.

RESULTS

As we studied the spectrum of aortic diseases only in adult patients, we included patients more than 14 years of age. The age range of cases varied from 14 years to 83 years with maximum number of cases (20%) in 31-40 years age group. 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. In the spectrum of aortic pathologies, 13 patients (26 %) were of congenital category and 37 patients (74%) were from acquired category.100% patients had normal origin of aorta from left ventricle. None of the patient in our study had anomalous origin.46 (90 %) of patients had normal number of cusps in aortic valve (tricuspid). 2 patients (4 %) had cusp morphology of bicuspid type. Other 2 patients (10%) had prosthetic aortic valve replacement. Out of 50 patients, 4 patients (8%) had diseased valve in form of leaflet thickening and valve stenosis. Out of these 4 patients, 3 patients (75%) had associated calcification of valve leaflets. One patient (25%) had non calcified thickened valve, associated with takayasu arteritis. All the patients (100%) included in our study had normal left sided aortic arch. There were no patients who had anomalous direction of the arch.23 patients (46%) had involvement of thoracic aorta only. Only 1 patient (2%)

was found to have abnormal communication between aorta and adjacent vascular structure. This one patient had patent ductus arteriosus type C (Tubular type without any constrictions).9 Patients (18%) had abnormal branching pattern of aortic arch. 2 patients (4%) had aberrant right subclavian artery with formation of vascular ring. 2 Patients (4%) had Bovine arch configuration in the form of common origin of brachiocephalic artery and left common carotid artery.2 patients (4%) had vascular ring. Both patients had aberrant right subclavian artery.

Table 1: Spectrum of aortic diseases by 128-slice CT Angiography

	No. of patients	Percentage
Origin		
Normal (from LV)	50	100
Overriding	0	0
Common trunk	0	0
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
Segment involved		
Thoracic only	23	46
Abdominal only	3	6
Both	22	44
Only branches	2	4
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

13 patients (26%) had aortic dissection. Out of these, 5 patients (38.5%) had Stanford type A dissection (involvement of ascending aorta) and one patient (61.5%) had Stanford Type B dissection. Out of 5 patients with Type A dissection, one patient also had infrarenal aortic aneurysm. This patient had also undergone Bentall's procedure for aortic root replacement. One of the patient of type A dissection also had partial thrombosis of the false lumen. 2 of the 5 patients who had type A dissection had their right renal artery originating from false lumen. Out of 8 patients who had Stanford type B dissection, 2 patients had traumatic dissection starting at the isthmus with hemothorax. Only one patient amongst these had thrombosis of false lumen. One of the patient had patent stent in descending aorta which showed type I endoleak. One of the patient had dissection involving only the infrarenal abdominal aorta.

Table 2: CT features of aortic dissection (True vs False Lumen) (n=13)

CT Findings	True lumen	False Lumen
Beak sign	0 (13)	10 (13)
Outer wall calcifications	0 (13)	0 (13)
Intraluminal thrombus	0 (13)	2 (13)
Eccentric flap calcification	0 (13)	0 (13)
Cobwebs	0 (13)	4 (13)

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. 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. 11 patients (68.75%) had involvement of thoracic aorta. 4 (25%) patients had involvement of abdominal aorta. One (6.25%) patient had aneurysms involving both thoracic and abdominal aorta. 8 patients had presence of thrombus within aneurysm sac. 8 patients had involvement of branch vessels, 5 patients had involvement of aortic root. Morphological features of all aneurysm and associated complications were very well detected on CT Angiography. 6 patients had complications related to aortic aneurysm. 1 patients had contained rupture into retroperitoneum, 2 patients had mass effect. (SVC compression in one patient and compression on carina, vertebral erosions in other patient. One patient had dissection and one patient had mycotic aneurysm. 3 patients had been treated with stent graft placement in aneurysm. All the patients had patent stent. One patient had trouser type of stent.

Table 3: Analysis of patients with Aneurysm

Aneurysm	No. of patients	Percentage
Type		
True	15	93.75
Pseudo	1	6.25
Saccular	3	18.75
Fusiform	13	81.25
Single Aneurysm	14	87.5
Multiple Aneurysm	2	12.5

Location		
Thoracic	11	68.75
Abdominal	4	25
Both	1	6.25
Others	0	00
Presence of thrombus	8	50
Involvement of branch vessels	8	50
Involvement of aortic root	5	31.25
Complication		
Rupture	1	6.25
Mass effect	2	12.5
Dissection	2	12.5
Infection	1	6.25
Post intervention	3	18.75

Out of 21 patients with atherosclerosis, most common imaging finding was wall calcification. It was seen in all the patients having atherosclerosis. Irregular vascular contour was found in 57.14% of patients. 47.61% of patients had aortic stenosis related to atherosclerosis.

Table 5: CT Angiographic features of atherosclerosis (n=21)

Morphological Features	No. of patients	Percentage
Irregular vascular contour	12 (21)	57.14
Calcification	21 (21)	100
Tortous vessel	5 (21)	23.80
Stenosis	10 (21)	47.61
Saccular dilatation or aneurysm	10 (12)	47.61
Penetrating Ulcers	2 (21)	9.52

DISCUSSION

CT angiography (CTA) has been widely used in the diagnostic evaluation of many cardiovascular diseases, and this technique currently serves as the first line modality in the early diagnosis of aortic diseases. In our study, 100% patients had normal origin of aorta from left ventricle. 90%patients had normal left sided aortic arch. 8% patients had abnormal branching pattern of aortic arch. 4% patients had aberrant right subclavian artery with formation of vascular ring. 4% Patients had Bovine arch configuration in the form of common origin of brachiocephalic artery and left common carotid artery. According to Layton KF *et al* bovine arch is a misnomer. They described that Standard Aortic Arch i.e. normal configuration occurs in approximately 70% of patients. Common origin of the Innominate Artery and Left Common Carotid Artery is seen in approximately 13% of patients, and this configuration replaces the misnomer of a "bovine" arch.[4]Malone CD did a study and concluded that Bovine arch should be considered a potential risk factor for thoracic aortic aneurysm.[5] In our 2 cases of bovine arch, aortic aneurysm was not seen in one patient. Vascular rings are uncommon anomalies (<1% of all congenital cardiac defects) with a similar frequency in both sexes. In our study 4% patients had vascular ring. In these patients abnormal/aberrant vessel (right subclavian artery)was coursing posterior to oesophagus. 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.[6]According to Lowe GM *et al*, CT and MRI add valuable information about exact arch configuration, tracheobronchial compression, brachiocephalic vessel branching.[7] Some type of abnormal communication between aorta and adjacent vascular structure was found in 2% patients. This patient had patent ductus arteriosus of type C. According to Schneider DJ *et al*,PDA constitute 5-10% of all congenital heart disease.[8]Accurate morphology of duct could be delineated using CT Angiography. Our patient had type C (tubular type without any constrictions).According to Krichenko A *et al*, Type A is the most common type of PDA.[9]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.[10] 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.[3,6] 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.[11] In addition, multiple congenital cardiovascular abnormalities are associated with a bicuspid aortic valve, notably, coarctation of the aorta.[12] 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.[13] 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.[14] 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.[15] 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.[16] CT provides complete imaging of the thoracic aorta, whereas TEE does not. New MDCT scanners allow synchronous imaging with the cardiac cycle, thereby reducing artifacts in the ascending aorta and the aortic root. 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. According to Hardman RL *et al*, MDCT allows less-invasive assessment of aortoiliac occlusive disease over classic angiography.[17]

CONCLUSION

CT angiography is one stop shop for both intra and extraluminal aortic pathologies. 128-slice CT scanner generates better quality images with minimum amount of radiation as compared to previous generation CT.All CT examinations should be done using strict tailoring of protocol as per pathology and age of patient with following the principle of ALARA (As low as reasonably achievable).CT angiography should be used with confidence to follow up the patients who have undergone endovascular as well as surgical treatment for aortic diseases.

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